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PROSPECTS FOR THE APPLICATION OF MINERAL FERTILIZERS IN THE USSR

. V. TURCHIN, Scientific Institute for Fertilizers, Insecticides, and Fungicides

Increasing crop yields is the main problem
acing our agriculture. A successful solution
epends to a very great extent on rational use
f mineral fertilizers, which are the chief
eans for increasing the fertility of the soil and
btaining, year after year, large yields in the
reater part of the Soviet Union.

Production and consumption of mineral
ertilizers in our country has been steadily in-
reased. Thus, in 1958 Soviet agriculture used
90,000 metric tons of nitrogen, 823,000 metric
ons of P_2O_5 in soluble phosphates, 208,000
etric tons of ground phosphorite, and 745,000
etric tons of K_2O. In terms of the standard
rtificial fertilizers, this amounted to 10.6
illion metric tons, as compared to 6.5 million
etric tons in 1953. This means a 62% in-
rease in the consumption of fertilizers in the
SSR over a period of 5 years.

In total production and consumption of mineral
ertilizers, the Soviet Union has surpassed all
estern European countries and is second only
the United States. However, because of the
ge size of the area in crops, the present level
fertilizer production has permitted us to ap-
y large amounts of mineral fertilizers only to
ch important commercial crops as cotton,
gar beets, tea, flax, etc., sharply increasing
eir yields. Grains and other food and forage
ops have received thus far very limited
mounts of fertilizers, not sufficient to satisfy
eir extremely great needs.

The current seven-year plan, from 1959 to
965, heralds a new phase in the development of
e Soviet chemical industry. During this period
number of fertilizer factories will be built and
rtilizer production will more than triple as
mpared to 1958. By 1965 Soviet agriculture
ill be consuming the following quantities of
ineral fertilizers: about 2.1 million metric
ns of nitrogen, 2.9 million metric tons of
$_2O_5$ (including about 2.1 million metric tons of
luble phosphates and 0.8 million metric tons
ground phosphorite, and 2.2 million metric
ns of K_2O. In terms of our standard artificial
rtilizers, this will amount to about 31 million
etric tons. Approximately 23 million metric
ns of this total amount will be applied to grains
d other food and forage crops. This fact will
ay a very important role in raising the total
rvest of grain, potatoes, vegetables and
rage crops in our country. Since the application of fertilizers promises to be most effective in the non-chernozem regions and in the adjacent forest-steppe regions not affected by droughts, this is where most of the fertilizers should be channeled. Best results would be obtained by applying all fertilizers. However, it should be remembered that these areas need nitrogen first of all. As a rule, when used without nitrogen, phosphorous and potassium fertilizers are relatively ineffective. The same areas have revealed a need for such micronutrient fertilizers as boron, cobalt, and molybdenum.

It has been demonstrated by scientific experiments and production records of the leading sovkhozes and kolkhozes that average yields per hectare equal to 30 cntr of grain, 220-250 cntr of potatoes, 350-400 cntr of corn silage and large harvests of other crops, could be obtained in the non-chernozem and humid forest-steppe regions, provided that they receive enough fertilizers and are cultivated properly.

The Far East and Eastern Siberia constitute another major area where application of all kinds of mineral fertilizers promises big returns.

In areas of thick and ordinary chernozem or chestnut soils, which do not have enough moisture, crop yields depend first of all on properly timed measures to accumulate and conserve soil moisture. This is true of most of the steppe and eastern forest-steppe regions. Application of nitrogen fertilizers here is usually not very effective. Best results can be obtained by using phosphorous fertilizers, particularly in the form of granulated regular or double superphosphate applied in small amounts (10 kg of P_2O_5) to the seed rows at the time of sowing. When superphosphate is thus applied, the average yield increase amounts to 2 cntr per ha. This method of application of phosphorus stimulates plant development during the early phases of growth, helping them to withstand better the adverse effects of drought. The current seven-year period will see this method of superphosphate application used over a large area of grain crops.

Thus, in the near future the geographical distribution of mineral fertilizers in our country will be considerably changed. However, in spite of this sharp increase in the production of fertilizers between 1960 and 1965, they will still be in short supply. By 1965 the area in crops in the regions not affected by droughts, will alone be at least 100 million ha. That means that about 5.5-6.0 million metric tons of nitrogen, 4.5 million metric tons of P_2O_5, and 6.0 million metric tons of K_2O would be needed to satisfy the normal requirements for fertilizers of only the non-drought and the irrigated regions. Considerable additional amounts of fertilizers would be needed for the arid regions (phosphorus), as well as for the natural meadows and pastures (potassium, nitrogen, phosphorus) in order to increase their productivity. More accurate estimates made by many scientific institutions show that after 1965 the Soviet Union will need about 75 million metric tons of mineral fertilizers to satisfy fully all agricultural requirements. This amount of fertilizers would be sufficient to assure a total yield of 240-250 million metric tons of grain, 200 million metric tons of potatoes, 65 million metric tons of sugar beets, and 10 million metric tons of raw cotton. It would be sufficient to provide an adequate forage supply for a highly productive animal industry.

During this seven-year period and the following decade (1965-1975) there will be not only an increase in the total production and consumption of mineral fertilizers, but also a major change in their variety. In addition to the currently available ammonium nitrate, ammonium sulfate, and superphosphate, we will be mass producing new kinds of fertilizers. Thus, urea will be one of the major nitrogen fertilizers. Urea is known as a "solid" nitrogen fertilizer of the highest concentration. When granulated, it has better physical and chemical properties and serves better as a component of combined fertilizers than ammonium nitrate. Urea can be used as a base in making the nitrogen fertilizers (products of combined condensation and formaldehyde) which cannot be leached out by water and are, therefore, very much needed for very wet areas (Transcaucasus, western regions) and for the irrigated cotton-growing regions.

The following liquid-nitrogen fertilizers will be produced in large quantities: liquid ammonia, ammonium water, ammonia solutions. Their application promises to be economically very advantageous for agriculture. In addition to liquid fertilizers containing nitrogen only, which are already being applied, there will be many complex liquid fertilizers containing ammonia, thermophosphoric acid, and potassium salts.

Superphosphate will be the most important phosphorous fertilizer because it has a high degree of concentration, can be used for all soils and plants, and can be applied in various ways (general application, placement application in rows, etc.). Ammonium phosphates, ammophos and diammonium phosphate, containing up to 60%-70% nutrients ($N + P_2O_5$) will be widely used. In addition to these two main phosphorous fertilizers, thermophosphates (defluorinated and fused magnesium phosphates) will also be produced. The quantity of phosphatic slags produced by metallurgical plants will be sharply increased.

Potassium sulfate will be a new potassium fertilizer. It will be produced in sufficient quantities to satisfy the needs of all crops sensitive to chlorides.

Finally, the production of compound and mixed fertilizers, the need for which is constantly growing, will be greatly increased. The lack of such fertilizers, which contain various nutrients in needed proportions, makes necessary the laborious and wasteful operations of mixing fertilizers on the farm. According to production estimates, concentrated compound and mixed fertilizers should comprise not less than 40% of the total future production.

The new fertilizers are only a part of the whole picture. At present research is being done with the ultimate objective of developing formulations which would combine the properties of multiple nutrient fertilizers with those of insecticides, fungicides, and herbicides. Presumably these formulations would provide plants with all needed nutrients simultaneously, protect them against disease and pests, and the fields of weeds.

Construction plans call for all new factories to be specialized primarily in the production of fertilizers with a high concentration of nutrients. This will considerably reduce transportation, storage and application of fertilizer.

To provide for easier handling and better keeping qualities, the compound and mixed fertilizers of ammonium nitrate, urea, and water-soluble phosphates, will be marketed only in the granular form.

Such are the prospects for the production and application of mineral fertilizers in our country in the near future. The importance of chemistry in increasing the crop yields is constantly growing. In many western European countries overall agricultural production has doubled or tripled owing to the application of mineral fertilizers. The realization of the planned increase in the production of mineral fertilizers in the Soviet Union will not only result in large crop yields, but will also sharply increase the productivity of labor in agriculture and lower the cost of production per unit area. According to the most conservative estimates, by 1965, when our fields will be receiving 31 million metric tons of mineral fertilizers per annum, the total value of the agricultural production will reach at least 75 billion rubles. And this expected gain will be many times more than the extra cost of the additional amounts of fertilizers. The application of fertilizers will also improve the quality of the crop yields. For example, proper application of nitrogen fertilizers could increase the protein content in wheat, rye, oats or corn 1 1/2—2 times. This would be very important to fill the growing protein needs of animal industry.

Received February 15, 1960

A MAP OF THE NATIVE SOIL-FORMING PARENT MATERIALS OF THE EUROPEAN PART OF THE USSR

P. N. CHIZHIKOV, Museum of Agriculture, Moscow State University

The Map of the Soil-Forming Parent Maerials of the European Part of the USSR, at a cale of 1:5,000,000, is based on information leaned from geological, soil science, and georaphical publications together with data comiled by the author himself during his expediions and, in particular, his work at experiment tations.

The map was produced at the Museum of Agriculture, Moscow State University. The oundaries of the parent materials were first lotted at a scale of 1:2,500,000 and then conerted to 1:5,000,000. The following data were sed: 1) individual district, region, and repubic maps of the soil-forming parent materials ompiled at different scales and published at ifferent times; 2) maps of Quarternary deosits; 3) soil maps, particularly those that ontain data on soil-forming parent materials;) various data from published sources and ata on lithology from research reports on soil tudies at experiment stations.

One might ask whether our map is different rom earlier maps showing Quarternary deposits, nd, if so, how it differs. The main differences re two. First, our map shows primarily the ithology of particular importance for soil formation. Secondly, it depicts only the thin ayer of material located at the very surface.

Earlier regional maps of soil-forming parent materials[1] were based on the lithology of that art of the soil profile in which specific features f the parent material, especially color, begin o predominate. Thus, very often the term "subsoil," as used on these maps, refers, not o the unaltered rock, but only to the part of he rock affected by the soil-forming process. ometimes lithology in the narrow sense only was mapped, i.e., only the texture of the deosits was given with no indication of their enetic classification. Arkhangel'skiy's (1) map of Penza Province, for instance, is such a map. But even the very oldest maps often conain in their legends references to the genetic roups of the soil-forming parent materials. During the post-Revolution period this has beome as mandatory as the indication of lithology. This is the only correct approach to the mapping of soil-forming parent materials, since the properties of the material, including the lithologic composition, depends to a large extent on its origin.

One of the first maps of this kind, was Tyurin's map of the Chuvash Republic (6). A map of Kalinin Region by Morozov (4), a map of Smolensk Region by Kuchinskiy (2) and maps of various other areas followed. Sobolev's (5) map of the entire Ukraine may serve as an example of the most complete. It gives information on the genetic groups of the parent materials, their lithology, and their age. On the other hand, maps of Quarternary deposits—both regional and composite—emphasize genetic groups and pay little attention to their lithology. The only exception is the first general map of the European Plain by Mirchink (3). The title itself, *Outline Map of Surface Quarternary Deposits*, shows that it indicates soil-forming parent materials. It was compiled from published materials and soil-research data available at that time. It shows both genetic groups and lithology. Because of this, Mirchink's map, even though it did not cover the northern and the northwestern district, should be regarded as the first general map of the soil-forming parent materials of the European Plain of the USSR. More recent general maps of Quarternary deposits have been made mostly on the basis of special studies of the deposits.

In 1932, a 1:2,500,00 map, entitled *Map of the Quarternary System Deposits of the European USSR and the Adjacent Territory*, was compiled by a large team of Quarternary geologists and edited by Yakovlev (7). A second improved and refined version at the same scale was published in a small number of copies in 1950. This is a map, not of the "surface" formations, but rather of the deep Quarternary geology, emphasizing genetic groups. The lithology on these maps, even though derived partly from Mirchink's map and soil studies, does not always correspond to the lithology of the formations at the surface. The latest map, edited by Yakovlev and published in 1956 (1:500,000), gives only genetic information (10). In his "Explanatory notes" to the 1932 map, Yakovlev (7) pointed out that, as far as this map was concerned, the soil had been "removed." Consequently, the removal also involved the surface geological formation—the parent materials on which the soil developed, i.e., the principal feature shown on our map. The map was compiled on the basis of observations of outcrops in ravines and river valleys. These data very often do not give a correct picture of what lies at the surface on slopes, but rather they describe the Quarternary complex.

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[1] The first map was compiled by N. M. Sibirtsev for he former Nizhniy Novgorod Province.

We used maps of the Quarternary deposits as a basic guide in entering the genetic groups on the maps of the soil-forming parent materials. Of course the general outlines duplicated the map of Yakovlev to a large extent. We took the boundaries between the genetic groups in the little-investigated north, and also between the fluvioglacial and alluvial deposits, from the latest map of 1956. But in those cases in which we had available data from soil studies which did not coincide with the genetic designations of the map of Quarternary deposits, we gave preference to the data. In solving the question of boundaries we gave principal weight to the lithology, since we are of the opinion that each group has its own characteristic lithology.

The limits of glaciation plotted on our original map were also taken from the latest map of Yakovlev (10). These, of course, must not be considered as absolute boundaries showing the age of the surface as one of the factors of soil formation, since after the deposit of each glaciation and in the post-glacial period geological processes continued to act on the surface of these deposits. But these subsequent processes were expressed differently above and below the boundary of glaciation.

Our map differs from maps of Quarternary deposits mainly in that it shows the lithology of each genetic group. The map shows by symbols and individual contour lines the following types of textures: sandy, sandy loam, sandy clay loam, loess-like silty clay loam, fine clay loam, and clay. Texture is considered of great importance as the most important characteristic of the materials giving rise to the soil and also to a greater or less extent indicating the origin of the parent material. Thus, subdivision of clay loams into sandy and silty types is important because this distinction is associated with the different origin of the materials.

The texture was taken from the data of soil studies and from soil maps. Of the soil maps, those which gave information on the parent materials were especially valuable. Among such maps are the soil map of White Russia and the individual 1:1,000,000 map sheets compiled by the Dokuchayev Soil Institute of the Academy of Sciences, USSR. What makes the textural data particularly reliable is the fact that they are derived from particle-size analyses over vast areas made by a single method. It should also be noted that the Kachinskiy modification of the pipette method used in this work was well suited for showing the differences among the genetic groups of the deposits.

In addition to texture, our map, in contrast to maps of Quarternary deposits, show areas with two-component parent materials (for example, the upper layer to a depth of 50 cm consists of hydroglacial sandy loam altered by soil formation, and below this is morainic material partially affected by soil formation). The underlying morainic material or parent material was also entered in those cases when it lay at depths of more than two meters, since even at this depth it still had an effect on the processes of soil formation.

In the south and southeast the map shows the salinity of the parent materials, their salinization with readily soluble salt being either weak or strong.

The genetic groups of deposits are shown on our map somewhat differently than on a map of Quarternary deposits. The eluvia of the native rock was given first place in the legend, since this is the source of the Quarternary deposits. The eluvia are subdivided into eluvia of massive crystalline rocks (acid and basic), chloritic schists, sandstones, shales, limestones, and other carbonate rocks. Because of the scale used, it was sometimes difficult to indicate on our map the small outlines of individual types of eluvium so they were lumped together as "mixed materials." The eluvium of native rock is found mostly in the mountainous regions and only rarely covers large areas on the plain.

Of course, not everything that we list as "eluvium" should be regarded as local weathering products, since surface conditions in the mountains seldom favor their retention in situ. Thus, within the lines showing eluvium, there are marks showing the various petrographic compositions for other little-studied formations which also move down the slopes in various ways (screes, deluvia, etc.). Yakovlev's map, however, shows all eluvium in one color.

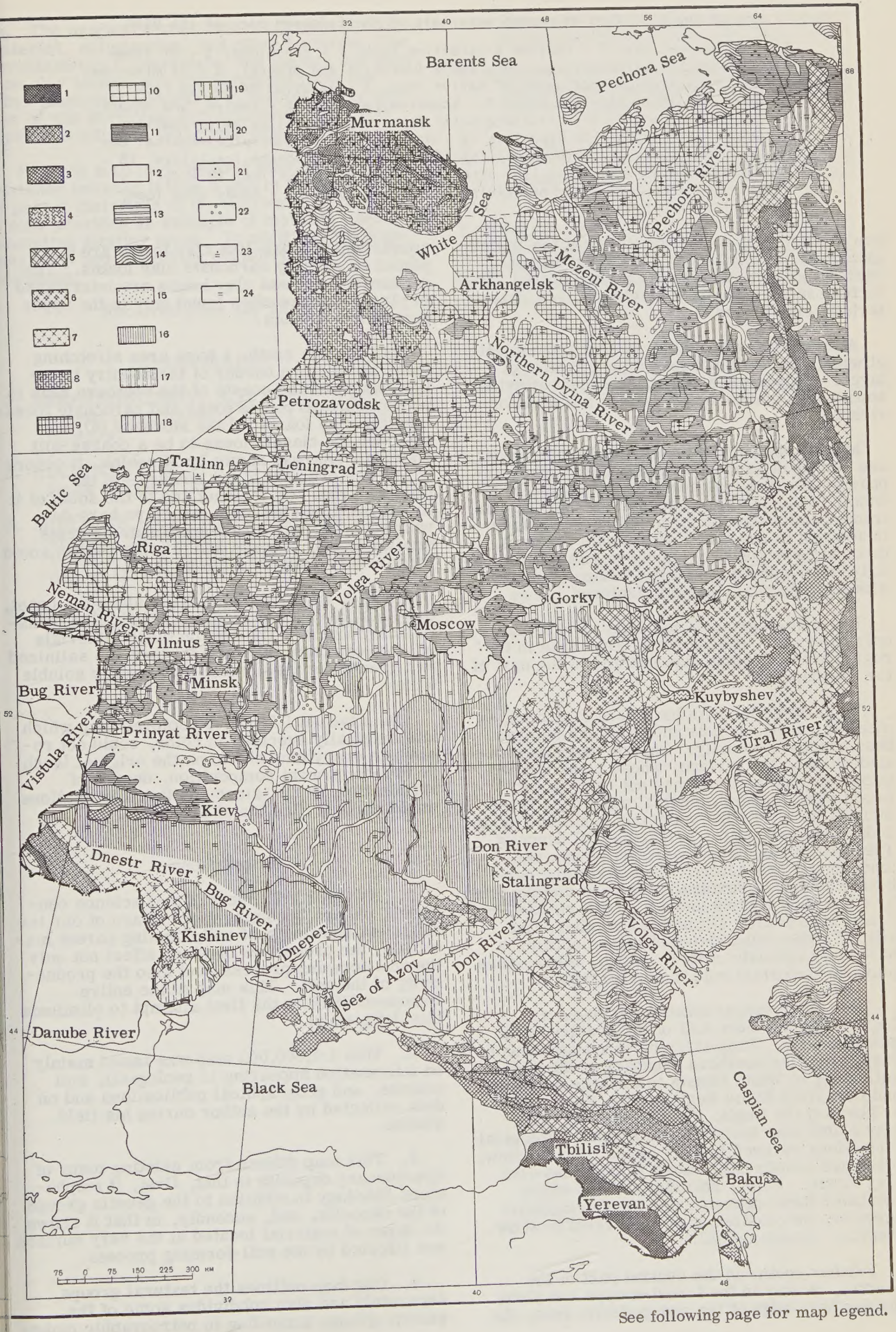
Next our legend shows the eluvium-deluvium of the native rock. This indication on the map refers to combinations and complexes of eluvium and deluvium of native rock in the eastern half of the country which individually do not occupy much area and hence could not be entered on our map. In districts where the deluvium of the native rock occupies large areas (the eastern and southeastern half of the country), they are shown individually. In deluvium areas, eluvium also is found in small elevated areas, but the areas occupied are small and hence not shown on the map.

Insofar as available data permitted, three very distinct types of morainic material were indicated. The most widespread is the Scandinavian moraine, which, on our map, because of the lack of sufficient information, is united with the Novaya Zemlya moraine and those of other glaciations and given a single color. The local carbonate morainic material, which has a pronounced influence on soil development in the north, is distinguished with a special lithological indication, as is the Karelian-Kola moraine, which has a coarse, gravelly, and largely sandy composition and is only slightly weathered.

Fluvioglacial deposits are shown on the map as being sandy ("zandry" [outwash plains]) and sandy loam or clay loam. The clay loam deposits include only sandy clay loams, while silty and loess-like clay loams are classified as "problematical" deposits, in contrast to Yakovlev's maps.

Lacustrine deposits (glacier water deposits)

MAP OF NATIVE SOIL-FORMING PARENT MATERIALS



See following page for map legend.

Map of the soil-forming parent materials of the European part of the USSR

Eluvium native rock: 1 - massive crystalline rock; 2 - sandstone; 3 - of limestone and other carbonate rock; 4 - shale (Jurassic and others); 5 - of mixed materials; 6 - eluvium - deluvium of native rock; 7 - deluvium of native rock. Moraine: 8 - local Karelian-Kola; 9 - Scandinavian, Novaya - Zemlya, and others; 10 - local carbonate; 11 - Fluvio-glacial deposits; 12 - alluvium (primarily ancient); 13 - lacustrine deposits; 14 - marine; 15 - eolian; problematical deposits; 16 - loess and carbonate loess-like; 17 - noncarbonate loess-like; 18 - weakly carbonate loess-like; 19 - strongly carbonate loess-like; 20 - syrt clays. Texture: 21 - sandy materials; 22 - sandy loam; 23 - sandy clay loam; 24 - silty clay loam.

are found mostly within the limits of the Kalinin glaciation. Their textural make-up is quite varied and most often they are well sorted. They include sand, loess-like clay loam, and characteristic clay lenses.

Alluvial deposits include recent and ancient alluvia. We could not follow the example of larger-scale maps and plot the recent alluvium separately, except in the valleys a few major rivers.

Marine deposits in the north along the coast are mostly of sand and sandy loam. They appear to have been redeposited and sorted by the wind. In the south, the deposits of the Caspian transgression are quite varied at the surface; in addition to sandy and sandy loam deposits, there are various clay loam deposits, including silty ones, and the so-called "chocolate clay" with its very characteristic features.

The aeolian group is indicated on our map only by sands. They cover a large area in the region of the Caspian deposits and to the east of the Caspian Sea.

All of these deposits have been long recognized as genetic groups and their names have been adopted generally. Certain deposits situated close to the surface, whose classification in one or another group has not been as yet established, occupy a special position. These include the loess-like materials combined by us under the designation "problematical deposits." They are distinguished basically by two very fundamental characteristics: texture and carbonate content. Texturally they are distinguished by a low sand content and a high silt content— in one case coarse silt and in the other, fine silt. Further subdivision of these deposits is based on carbonate content, which, with texture, plays an important role in soil formation.

Loess-like noncarbonate clay loams are found in the northern half of the country in the podzolic zone. They stretch, in a discontinuous band, from the southern boundary of the podzolic zone in White Russia toward the northeast, and then from Kirov Region to the Polar Urals and beyond the Urals. Our outlines of these clay loams also include those surface geological formations covered by clay loams. In our view, these are genetically related to the loess-like clay loams. Unlike Yakovlev's maps which combined these deposits with the fluvioglacial deposits, we consider it more correct to show them as "problematical."

Further south, in the central part of the country, mostly in the forest-steppe and along the southern edge of the sod-podzolic zone, the noncarbonate loess-like clay loams are replaced by slightly carbonate clay loams. The carbonates in these clay loams are interrupted in places and are often found only in the upper part of the stratum.

Still farther south, a huge area stretching from the western border of the country to the Don basin and the coasts of the southern seas is occupied by carbonate loess and carbonate loess-like fine clay loams. Like Morozov (4), we consider the classic loess to be a coarse-silt material. As was shown by Mirchink, it occurs in the western part of the country—in the Dnieper area. On the east and to the south of it fine loess-like clay loam and clays have developed. The latter have carbonate contents similar to that of loess and for this reason some researchers classify them as such.

Finally, in the extreme south along the coast, one finds strongly carbonate, chiefly fine loess-like clay loams. The soil on these materials effervesces from the surface; they are salinized to a greater or less extent with readily soluble salts.

The attached 1:7,500,000 colored map which was originally executed in color, could not reproduce everything shown on the original (such as two-component composition, degree of salinization, etc.), since additional indications would make it illegible at this scale.

Conclusions

1. As the development of soil science continues, we are becoming more aware of our insufficient knowledge of soil-forming parent materials, the properties of which affect not only the soil-forming process, but also the productivity of the soil. This map of the entire European USSR is the first attempt to eliminate this deficiency.

2. This 1:5,000,000 map was based mainly on information appearing in geological, soil science, and geographical publications and on data collected by the author during his field studies.

3. This map differs from existing maps of Quarternary deposits in that, first, it emphasizes lithology in addition to the genetic groups of the deposits, and, secondly, in that it shows the layer of material located at the very surface and affected by the soil-forming process.

4. Our map outlines the textural groups separately and also subdivides some of the genetic groups according to petrographic make-

up. The original shows two-component parent material, salinization, and other features. The "problematical" materials, the loessic and surface clay loams, are distinguished from the other materials according to texture (their content of silt particles) and are divided into five types according to carbonate content.

5. This map is of general educational importance because it fills a gap in the treatment of parent materials in the soil science course. It also provides an example of methods used in compiling similar maps. In addition, the map may be of use in solving certain practical problems.

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BIBLIOGRAPHY

1. ARKHANGEL'SKIY, A.D. 1916. A geological description of Penza Province. Moscow.

2. KUCHINSKIY, P.A. 1950. Soils of Smolensk Region. Smolensk.

3. MIRCHINK, G.F. 1928. The state of the study of the Quarternary surface formations in the European USSR. Pochvovedeniye, (23):1-2.

4. MOROZOV, S.S. 1939. Soils and soil-formation conditions in Kalinin Region. Uchenyye zapiski Moskovskogo Gosudarstvennogo Universiteta, No. 29.

5. SOBOLEV, S.S. 1935. The soil-forming parent materials of the Ukrainian SSSR. Pochvovedeniye, No. 4.

6. TYURIN, I.V. 1935. The conditions of soil-formation and a brief description of the soils of the Chuvash Republic. Moscow—Leningrad.

7. YAKOVLEV, S.A. 1932. A map of the Quarternary system deposits of the European USSR and adjacent territories at a scale of 1:2,500,000. Explanatory note. Moscow—Leningrad.

8. YAKOVLEV, S.A. 1948. Map of the Quarternary system deposits of the European USSR. Trudy 2-go geograficheskogo s"yezda.

9. YAKOVLEV, S.A. 1950. A map of the Quarternary system deposits in the European USSR and adjacent territories at a scale of 1:2,500,000.

10. YAKOVLEV, S.A. 1956. A map of the Quarternary system deposits of the European USSR and adjacent territories at a scale of 1:2,500,000.

CHERNOZEMS OF THE TRANS-ILI ALA-TAU

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The Trans-Ili Ala-Tau is a mountain range with a distinct vertical soil zonality and a wide chernozem belt. The soil of the range has been described by Krasnov (13), Bezsonov (2, 3, 4), Abolin (1), Pavlov (14), Glazovskaya (5, 6, 7), Sokolov (16, 17), and Chulakov (18, 19), however, there is no published work especially devoted to its chernozem.

The Trans-Ili Ala-Tau range belongs to the Tyan'-Shan' system. The total length of the range is about 180-200 km. The highest elevations are concentrated in its central part. Its highest point, the Talgar Mountain, has an absolute elevation of 5017 m. The chernozem belt is located on the northern slopes of the range at an absolute elevation of 900-1500 m and occupies primarily the areas of the so-called "table-land." The table-lands are lateral branches of the main range having the shape of rounded hills which gradually slope toward the north. These table-lands are one of the main reasons for the pronounced vertical soil zonality. Because of them the surface rises more gently allowing for a more gradual change in natural conditions, such as climate and vegetation.

Unlike the Western Caucasus and especially the Alps which are under the influence of seas (with the result that individual soil zones, especially steppe soil zones, are displaced, or lack, in the vertical series), the Trans-Ili Ala-Tau, which is far from the sea, is not subjected to such outside influences. Therefore the role of relief in soil formation comes to full development here. The following clearly pronounced soil zones, changing with absolute elevation, are found in the Trans-Ili Ala-Tau: sierozem, chestnut soils (with light-chestnut and dark-chestnut subzones), chernozem and forest-steppe, mountain-forest, and mountain-meadow zones.

According to our calculations, the chernozem zone in the foothills covers about 300,000 ha, whereby approximately 30%-35% of this area is occupied by other soil groups, such as: gray forest soils under forests in the subzone of chernozem rich in humus; underdeveloped gravelly soils on steep slopes; and also alluvial soils covering alluvial zones. Chernozems occupy the tops of the table-lands and their northern and eastern slopes. Underdeveloped gravelly soils are found on southern and western slopes which are steeper than the northern and eastern slopes and where solid rocks crop out.

The climate of the chernozem zone in the foothills of Trans-Ili Ala-Tau is sharply continental. According to data of the Alma Ata meteorological station, the mean annual temperature is 7.8°C, the mean temperature in January is -8.3°C, and in July is +23.0°C. Thus, the mean amplitude of temperature variations is 31.3°C, which is indicative of continental climate. The foothills of the Trans-Ili Ala-Tau are subject to late spring and early autumn frosts which shorten the growing period. The mean annual amount of precipitation is 561 mm. There is a very pronounced spring precipitation maximum amounting to 42.1% of total precipitation.

The soil-forming parent material here is loess, underlain at a depth of several tens of meters by tertiary clay, or even by older solid materials.

Vegetation consists of grasses and mixed herbage. Herbaceous vegetation is dense and reaches a height of 0.5 m and more. As has been pointed out by Krasnov (13), the species composition of vegetation here is almost identical to that in the chernozem zone of the Russian plain. Pavlov (14) also notes that at least 80% of all plant species represented here are also found in the Russian Plain.

In the upper part of the chernozem zone small birch and aspen stands alternate with open areas. This part of the chernozem belt is an unusual mountain forest-steppe. A large part of the natural herb vegetation in the chernozem belt of the foothills of the Trans-Ili Ala-Tau has been destroyed by plowing.

All three subzones are found in the chernozem zone of the Trans-Ili Ala-Tau: slightly humic, moderately humic, and very humic chernozems. Those subzones alternate with each other with the increase in absolute elevatio the very humic chernozems occupy the forest-steppe in the highest part of the chernozem belt.

Leached chernozems predominate in the subzone of very humic chernozem. This is due to the fact that this subzone is located in a more humid climate than the other subzones. Typical chernozems predominate in the subzone of moderately humic chernozem. In addition, there are some leached chernozems here, but they are less-common than in the subzone with very humic chernozem. In both subzones leached chernozems are mostly found on northern slopes where the microclimate is more humid. Typical and carbonate chernozems predominate in the subzone with slightly humic chernozem. There are almost no leached chernozems in this zone because of the drier climate. There is no solonetzic chernozem in the foothills of the Trans-Ili Ala-Tau, which can be explained by sufficient moisture, the dissection of the surface and the good natural drainage associated with it, as well as by the absence of salt-bearing soil materials. Because of these same reasons there are no solonchaks, solonetzes, or solods in the Trans-Ili Ala-Tau chernozem zone. All the previously-described chernozems are fine clay loam and clay loam.

The subzone with very humic chernozem is located at an absolute elevation of 1,200-1,500 m and is 10-15 km wide. According to our calculations, it occupies 48.7% of the entire chernozem zone of the Trans-Ili Ala-Tau foothills. Typical chernozems occupy 37% and leached chernozems, 63% of the subzone of very humic chernozem.

According to our mean arithmetic data, the average thickness of the A horizon of very humic, typical chernozems is 33 cm and that of very humic leached chernozems, 38 cm. The average thickness of the A + B_1 horizon is 57 cm and 63 cm, and of the A + B horizon, 96 cm and 102 cm, respectively.

Thus, the very humic leached chernozems have a thicker A horizon and, in general, a better developed profile, since because of leaching, the soil formation process embraces the deeper horizons.

The mean depth of effervescence is 54 cm in the very humic, typical chernozems and 96 cm in the very humic, leached chernozems. As we can see, the very humic leached chernozems effervesce at a much greater depth.

The characteristic morphological features of very humic chernozems are the intensely black coloration of the A horizon (owing to the considerable amount of humus), a pronounced fine-granular structure, and the very gradual transition from one horizon to another.

The Trans-Ili Ala-Tau chernozem is characterized by the absence of humus tongues and intrusions in the transition horizons. The intensity of the color decreases very gradually with depth. This is typical not only of very humic chernozem, but of all the chernozems examined. Leached chernozems differ from typical chernozems not only by the depth of effervescence, but also by their characteristic morphological features: brownness and compaction of the lower part of the A horizon and of the entire B horizon, the coarser structure of this horizon, and an even more gradual transition from one horizon to another.

The moderately humic chernozem subzone is located at an absolute elevation of 1000-1200 m and reaches a width of 5-6 km. It occupies about 23.3% of the entire chernozem zone.

Typical and leached chernozems are found in this subzone, as in the very humic chernozem subzone. The first occupy 72% and the latter, 28% of this subzone. The average thickness of the A horizon here is 32 cm for the typical and 33 cm for the leached chernozems. The average thickness of the A + B_1 horizon is 58 cm and 60 cm, and that of the A + B horizon 93 cm and 106 cm, respectively.

The depth of effervescence averages 59 cm for the typical and 93 cm for the leached chernozems.

Thus, the moderately humic leached chernozems, as the very humic leached chernozems, have somewhat thicker genetic horizons. These chernozems are generally distinguished from typical moderately humic chernozems by the same features as very humic leached chernozems.

The slightly humic chernozems are located at an absolute elevation of 900-1000 m and occupy 28% of the entire chernozem zone in the foothills of Trans-Illi Ala-Tau. Of this, 79% is occupied by typical and 21% by carbonate chernozems. The average thickness of the A horizon is 31 cm in the slightly humic typical and 30 cm in the slightly humic carbonate chernozems. The average thickness of the A + B_1 horizon is 54 cm and 50 cm, and that of the A + B horizon 82 cm and 81 cm, respectively. The slightly humic typical chernozems effervesce from an average depth of 38 cm, while the carbonate counterpart effervesce from the surface.

Thus slightly humic chernozems have somewhat thinner genetic horizons than moderately humic and, especially, very humic chernozems. This is most noticeable in the A + B horizon. In general, however, as may be seen from our data, moderately thick chernozems predominate among chernozems of the foothills of the Trans-Ili Ala-Tau.

It must be noted that the separation of carbonates in the form of pseudo-mycelium is typical of all chernozems of the Trans-Ili Ala-Tau. The separation of carbonates in the form of white specks, which is characteristic for the majority of chernozems in other regions, is completely absent here.

Let us examine the physicochemical characteristics of Trans-Ili Ala-Tau chernozem as given in Tables 1, 2 and 3. Table 1 shows the differences between the humus content of very humic, moderately humic, and slightly humic chernozems. Almost all profiles in Table 1 show a peculiar phenomenon consisting in the sharp decrease in the humus content between the A and B_1 horizons. This decrease is especially conspicuous in Profile 1 (very humic typical chernozem), Profiles 4 and 18 (very humic leached chernozem), Profile 12 (moderately humic leached chernozem), and other profiles. This phenomenon must be considered typical for Trans-Ali Ala-Tau chernozem. It is not found in the chernozems of the Cis-Caucasia and the Russian Plain. After this abrupt decrease, the decrease of humus with depth occurs more gradually.

We are inclined to agree fully with Glazov-

Table 1

Basic analytical data on chernozems of the Trans-Ili Ala-Tau foothills

Profile No.	Depth, cm	Chernozem and its location	Humus	Total nitrogen	C : N	Total phosphorus	Carbonic acid	pH	Particle diameter		Water extract, %		Exchangeable cations, % of the total			Sum of exchangeable cations, meq	Sum of sesquioxides from a 10% hydrochloric extract
			%	%		%	%		< 0,001	< 0,01	Solid residue	Total alkalinity	Ca	Mg	Na		
1	0—10	Very humic, fine clay loam. Kolkhoz "Alatau," Alma-Ata Region. Summit of a rolling hill. Virgin land. Mixed herb-grass steppe.	9,61	0,67	8,3	0,26	Does not effervesce	7,3	23,4	51,0	0,217	0,034	89,3	10,7	none	35,6	9,42
	15—25		7,53	0,56	7,6	0,25		7,2	23,6	49,8	0,167	0,027	85,4	14,6	"	31,5	9,82
	30—40		4,65	0,39	6,9	0,23	"	7,2	24,2	49,9	0,165	0,038	90,4	9,6	"	25,4	10,25
	50—60		3,46	—	—	—	3,5	7,5	23,7	49,6	0,140	0,042	87,8	12,2	"	23,8	10,52
	75—85		2,70	—	—	—	6,7	7,7	24,5	49,9	0,199	0,032	87,5	12,5	"	23,6	10,72
	150—160		1,06	—	—	—	12,4	7,8	18,8	39,3	0,217	0,043	—	—	—	—	9,22
4	1—10	Very humic, leached fine clay loam, Kolkhoz "Ala-Tau," Alma-Ata Region. Northern slope. Field	11,08	0,80	8,0	0,27	Does not effervesce	7,0	22,4	53,5	0,152	0,031	96,1	3,9	none	31,9	6,49
	15—25		9,67	0,61	9,2	0,24		6,8	22,9	55,2	0,109	0,034	94,3	5,7	"	31,2	9,46
	45—55		3,75	—	—	—	"	6,6	25,2	59,3	0,179	0,031	89,9	10,1	"	24,5	11,20
	75—85		1,76	—	—	—	"	6,8	22,5	56,2	0,197	0,037	84,5	15,5	"	22,8	11,83
	140—150		0,63	—	—	—	12,1	7,9	20,8	40,3	0,207	0,042	—	—	—	—	7,77
18	0—10	Very humic leached fine clay loam. Kalinin Kolkhoz, Alma-Ata Region. Summit of a rolling hill. Virgin land. Mixed herb-grass steppe.	11,24	0,72	9,0	0,31	Does not effervesce	7,0	Not det'd.		0,114	0,029	95,8	4,2	none	39,6	8,92
	15—25		10,21	0,67	8,8	0,24		7,1	"		0,128	0,027	91,9	8,1	"	36,8	9,82
	40—50		3,87	—	—	—	"	7,0	"		0,114	0,025	—	—	—	—	11,37
	80—90		1,78	—	—	—	"	7,1	"		0,177	0,025	—	—	—	—	10,21
	150—160		0,57	—	—	—	12,9	7,7	"		0,190	0,037	—	—	—	—	7,09
11	0—15	Very humic leached clay loam NW slope. Virgin land. Mixed herb-moss steppe.	11,47	Not det'd.			Does not effervesce	6,3	9,8	38,3	Not det'd.		91,0	9,0	none	42,4	—
	20—30		5,66	"				6,4	12,4	44,7	"		87,7	12,3	"	28,7	—
	45—55		4,05	"			"	6,3	12,4	49,3	"		88,3	11,7	"	26,5	—
	80—90		3,07	"			"	6,8	12,5	46,3	"		84,8	15,2	"	25,4	—
	120—130			"			11,2	7,5	10,4	39,4	"		—	—	"	—	—
	160—170			"			11,7	7,8	10,9	39,3	"		—	—	"	—	—

Note: Comma represents decimal point.

Table 1 continued

Profile No.	Depth, cm	Chernozem and its location	Humus	Total nitrogen	C : N	Total phosphorus	Carbonic acid	pH	Particle diameter		Water extract, %		Exchangeable cations, % of the total			Sum of exchangeable cations, meq	Sum of sesquioxides from a 10% hydrochloric extract
			%			%			< 0,001	< 0,01	Solid residue	Total alkalinity	Ca	Mg	Na		
13	0—10	Moderately-humic fine clay loam. Kolkhoz "Alatau," Alma-Ata Region. Summit of a rolling hill. Virgin land. Mixed herb-grass steppe.	7,61	0,50	8,8	0,20	Does not effervesce	7,2	21,7	51,9	0,149	0,034	89,8	10,2	none	29,5	8,77
	15—25		4,88	0,31	9,1	0,19		7,4	19,5	52,3	0,123	0,030	90,2	9,8	"	25,7	8,13
	35—45		2,68	—	—	—	"	7,2	20,3	50,9	0,194	0,034	90,7	9,3	"	25,5	9,24
	60—70		2,08	—	—	—	4,5	8,2	20,9	43,7	0,184	0,036	—	—	"	—	8,46
	120—130		0,74	—	—	—	11,1	8,3	12,2	40,4	0,219	0,047	—	—	"	—	8,60
12	0—10	Moderately humic leached fine clay loam. Kolkhoz "Alatau," Alma-Ata Region. Northern slope. Alfalfa field (5 years).	8,66	0,72	7,0	0,30	Does not effervesce	6,5	22,3	50,2	0,114	0,027	90,1	9,9	none	29,3	6,97
	15—25		6,11	0,47	7,5	0,27		6,7	24,3	51,1	0,161	0,036	89,5	10,5	"	24,0	9,80
	40—50		2,32	—	—	—	"	7,0	25,6	54,2	0,189	0,036	92,0	8,0	"	20,5	10,35
	75—85		1,38	—	—	—	"	7,2	24,9	48,4	0,184	0,026	91,9	8,1	"	18,6	10,83
	135—245		0,75	—	—	—	13,9	7,9	21,3	46,9	0,224	0,040	—	—	"	—	6,76
27	0—10	Slightly humic fine clay loam. Kalinin kolkhoz. Alma-Ata Region. Summit of a rolling hill. Virgin land. Grass steppe.	5,99	0,52	6,7	0,23	Does not effervesce	7,8	Not det'd.		0,142	0,031	87,5	12,5	none	22,8	8,93
	15—25		3,74	0,42	5,1	0,22		7,7	"		0,145	0,039	91,9	8,1	"	21,9	9,68
	40—50		2,37	—	—	—	"	7,7	"		0,160	0,036	—	—	"	—	8,54
	60—70		1,18	—	—	—	5,2	7,8	"		0,184	0,044	—	—	"	—	7,37
	110—120		0,51	—	—	—	11,0	7,9	"		0,211	0,048	—	—	"	—	7,05
52	0—10	Slightly humic carbonate clay loam. Kaskelensk district. Alma-Ata Region, Northern slope. Virgin land. Grass steppe.	5,20	0,42	7,2	0,19	2,8	Not det'd.	18,6	46,9	0,179	0,042	81,5	10,6	2,9	22,5	Not det'd.
	20—30		5,10	0,34	8,7	0,11	3,9		15,1	40,8	0,158	0,045	87,0	10,8	2,2	20,5	
	40—50		2,25	—	—	—	5,9	"	19,1	40,1	0,161	0,044	86,2	10,8	3,0	18,0	"
	60—70		1,70	—	—	—	8,9	"	12,7	34,9	0,171	0,048	—	—	—	—	"
	90—100		1,00	—	—	—	13,7	"	14,4	27,8	0,235	0,042	—	—	—	—	"

Note: Comma represents decimal point.

Table 2

Group composition of humus in very humic chernozem in the foothills of Trans-Ili Ala-Tau

Profile No.	Depth, cm	Humus	Carbon	Composition of humus, % of total carbon			C of humic acid / C of fulvic acid
		%		Humic acids	Fulvic acids	Insoluble residue	
11	0—15	11,47	5,98	33,49	22,77	39,29	1,4
	20—30	5,66	2,96	46,00	20,33	27,37	2,6
	45—55	4,05	2,11	36,46	26,06	36,96	1,4
	80—90	3,07	1,61	28,56	37,30	35,40	0,8

Note: Comma represents decimal point.

skaya (6) who writes, in explaining the abrupt decrease in humus content between the A and B_1 horizons, that:

"The increased humic content in the upper horizons is probably associated with the climatic conditions in foothills. The soils of foothills receive much greater amounts of precipitation than the corresponding soils in plains. (The total amount of precipitation received by sierozems, chestnut soils and chernozems in the foothills is 1.5-2.0 times more than that received by corresponding soils in the plains). The seasonal distribution of precipitation is very uneven: most of it falls during winter and especially spring. The great amount of precipitation in spring causes a lush development of the vegetation. Even the foothill wormwood steppe on sierozem is densely covered with ephemeral and looks at this time like a colorful flowering meadow. As soon as summer sets in, the amount of precipitation decreases sharply. Prolonged dry spells occur, the vegetation dries up, and its excess residues find their way into the soil. During the dry period the complete mineralization of the organic matter is inhibited and it accumulates in the upper soil horizons. The leaching of the decay products into the deeper layers is also hindered because of the dryness of this period."

The group composition of humus in chernozems of the Trans-Ili Ala-Tau foothills is, as Table 2 shows, typical for all soils of the chernozem group. Except for the lowermost horizon, all other horizons show a prevalence of humic acids over the fulvic acids (the ratio of the C of humic acid to be C of fulvic acid reaches 2.6). We should note that these data are close to those obtained by Kononova (12) for the chernozems of the Russian Plain, but differ somewhat from Yemel'yanov's (11) data and our own (10) data for the chernozems of Northern Kazakhstan; group humus composition of the latter is characterized by a larger content of nonsoluble residue (humins). The humus of Trans-Ili Ala-Tau chernozems contains considerably less humin than the chernozems of Northern Kazakhstan because they form in more humid climatic conditions, under which humus retains its ability to be preserved.

The total nitrogen content in these soils is closely related to their humus content; it is highest in very humic chernozems and lowest in slightly humic chernozem.

It must be emphasized that all chernozems of the Trans-Ili Ala-Tau foothills contain more total nitrogen than the corresponding chernozem subgroups and varieties of the Russian Plain and Western Siberia, so that the ratio between carbon and total nitrogen content in them is much narrower than in the chernozems of other provinces, as can be seen from Table 3 and data published by us earlier (9). This ratio is narrowest in slightly humic chernozems. Table 3 also shows that the Trans-Ili Ala-Tau chernozems contain, on the average, more total phosphorus than the West Siberian chernozems. This is especially characteristic of very humic chernozems; less humic chernozems contain less total phosphorus, in general, than the more humic chernozems.

The deeper horizons of both the typical and leached chernozems contain a considerable amount of carbon dioxide (up to 13%-14%), whereby the horizon where carbonates accumulat is considerably deeper in the leached than the typical chernozems. Carbonate chernozems (Profile 52) contain carbonates throughout the entire profile and their content gradually increases with depth.

The results of pH determinations show a neutral, or very weak alkaline reaction for soil solutions of the upper horizons of typical chernozems and a weak acid reaction for the same horizons of leached chernozems. In both cases the pH increased with depth and the soil solution of the carbonate horizons of both typical and leached chernozems has a distinctly alkaline reaction.

The chernozems described are fine-textured, as evidenced by the considerable amount of <0.001 mm diameter particles (Table 1). Only the chernozems, characterized by Profile No. 11, are somewhat coarser in texture than the others. The texture of typical chernozems changes little along the profile; the intermediate horizons of leached chernozems, however, have generally a finer texture than the upper horizons because clay particles migrated into them. As far as the lowermost horizons of all chernozems

Table 3

Ratio of carbon to total nitrogen and the total phosphorous content in the chernozems of the Trans-Ili Ala-Tau foothills

Chernozem	Arithmetical mean					No. of cases
	Humus	Carbon	Nitrogen	C : N	Phosphorus %	
	%					
Very humic	10,37	6,07	0,75	8,0	0,35	10
Moderately humic	7,61	4,41	0,55	7,8	0,30	8
Slightly humic	4,63	2,69	0,37	7,3	0,23	9

Note: Comma represents decimal point.

re concerned, they are more finely textured han the upper and intermediate horizons; in articular they generally contain a lesser mount of clay particles.

The results of analysis of the water extract Table 1) confirmed that these chernozems are ot saline and solonetzic. The solid residue is mall; total alkalinity is insignificant, whereby eached chernozems contain less solid residue nan typical chernozems and are less alkaline. 'he alkalinity of carbonate chernozems is lightly higher than that of other chernozems.

Table 1 shows that the sum of exchangeable ations varies depending on the humus content. 'he most humic chernozems have the highest um of exchangeable cations. The adsorption omplex of the chernozems described (that of ll chernozems in general) is saturated with alcium and contains a comparatively small mount of exchangeable magnesium, the per entage of which sometimes increases somehat with depth. There is little adsorbed sodim. Only in the slightly humic carbonate cherozem, shown by Profile No. 62, contains a mall amount of exchangeable sodium, which, owever, is not sufficient to consider this cherozem as being solonetzic. The absence of exhangeable sodium in the chernozems described orroborates our earlier conclusion that there re no solonetzic chernozems in the foothills of ne Trans-Ili Ala-Tau.

It should be noted that according to Glazovkaya's data (16), the very humic leached cherozems in the Trans-Ili Ala-Tau foothills conins very little adsorbed hydrogen.

The sum of sesquioxides indicate that they ove along the profile of leached chernozems nd accumulate at a certain depth in intermedie horizons. Sesquioxides are distributed more venly in typical chernozems, and even if they ove slightly (Profile No. 1, for instance), this ovement is less significant than in leached hernozems.

The movement and accumulation of sesquixides at a certain depth are very characteristic leached chernozems and point together with her factors examined earlier, to the leaching rocess. As Table 1 shows, the horizons here sesquioxides accumulate most are the more finely textured.

As a result of the studies of the morphological features and physicochemical properties of the chernozems of the Trans-Ili Ala-Tau foothills it may be concluded that these chernozems have a number of features and properties common with chernozems of the Russian Plain. This fact permitted Krasnov (13) to state that "the Trans-Ili Ala-Tau foothill chernozems do not essentially differ from the good Simbirsk chernozem." However, they possess at the same time a number of special features the major of which, according to the foregoing data, are: the absence of distinct humus tongues and intrusions in the intermediate horizons, the separation of carbonates exclusively in the form of pseudomycelium, sharp changes in the humus content between the A and B_1 horizons, and a much narrower ratio between carbon and total nitrogen content.

A significant difference between the chernozem zone of the Trans-Ili Ala-Tau foothills and any other chernozem region of the USSR consists in the complete absence of solonetzic varieties, as well as solonchaks, solonetzes, and solods among local chernozems. The soil is homogeneous here within any chernozem subzone, if we disregard the occurrence of underdeveloped stony soils on steep slopes.

The insignificant occurrence of shallow chernozems is conspicuous and attributable to the richness of vegetation which protects the soil from erosion even on steeper slopes. Water erosion affects first of all the steep southern and western slopes. Because of their steepness and associated erosion, there is practically no chernozem on these slopes. Erosion on other relief elements occurs primarily as a result of the plowing of chernozems.

The chernozems of the Trans-Ili Ala-Tau foothills are fertile soils because of the saturation of their adsorption complex with calcium which insures the formation of a stable structure and a sufficient supply of nutrients. However, these chernozems occur under less favorable climatic conditions than chernozem of certain other regions, especially in the Cis-Caucasus. Maximum precipitation in spring, late spring and early autumn frosts, and intense evaporation associated with hot summers and the low pressure characteristics of mountain regions, worsen the climatic conditions and thus negatively affect the natural fertility of local chernozems. The uneven surface of the table-lands on which the described chernozems are located make their agricultural utilization difficult. In addition, it promotes water erosion, which, as was stated earlier, intensifies with plowing.

Nevertheless, the chernozems of the Trans-Ili Ala-Tau have a great economic importance. They are suitable for the most various crops, including heat-loving crops. Field crops, orchards and vegetables can be further developed here.

The productivity of the chernozems in the foothills of the Trans-Ili Ala-Tau could be increased by sowing perennial grasses, the high yield of which would be assured from the moist climate, and by taking all the measures necessary to conserve soil moisture. Special attention should be paid to forest belts as an effective means of controlling water erosion. The present irrigation practices in certain areas require the determination of optimum irrigation rates and the regulation of runoff from irrigation, since haphazard irrigation intensifies erosion.

It may be concluded from the foregoing that the outlook for the further development of agriculture in the chernozem zone of the Trans-Ili Ala-Tau is very promising.

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BIBLIOGRAPHY

1. ABOLIN, R.I. 1930. From the desert-steppes of the Balkhash to the snow-covered summits of Khan-Tengri. Trudy Instituta pochv i geobotaniki SAGU. No. 5. Leningrad.
2. BEZSONOV, A.I. 1916. Soil investigations in Verensk County of Semerechensk Region. Izdaniye Dokuchayevskogo pochvennogo komiteta. No. 2.
3. BEZSONOV, A.I. 1923. Materials on the classification of the mountain soils. Izvestiya Samarskogo sel'skokhozyaystvennogo instituta.
4. BEZSONOV, A.I. 1925. Soil of Dzhetysu. Tashkent.
5. GLAZOVSKAYA, M.A. 1945. The soils of the Trans-Ili Ala-Tau and the possibility of their agricultural utilization. Izvestiya Kazakhskogo Filiala Akad. Nauk, Ser. pochvovedeniya, No. 1-2.
6. GLAZOVSKAYA, M.A. 1946. Materials for the classification of soils on the northern slopes of the Trans-Ili Ala-Tau. Izvestiya Akad. Nauk Kazakhskoy SSR. Seriya pochvovedeniya. No. 3. Alma-Ata.
7. GLAZOVSKAYA, M.A. 1949. Soils of the mountainous regions of Kazakhstan. Izvestiya Akad. Nauk Kazakhskoy SSR. Seriya pochvovedeniya No. 4. Alma-Ata.
8. DOKUCHAYEV, V.V. 1899. Study of natural zones.
9. DURASOV, A.M. 1951. The ratio between carbon and the total nitrogen content in the chernozems of various provinces. Pochvovedeniye, No. 8.
10. DURASOV, A.M., V.P. YEGOROV, and I. I. YEGOROVA. 1957. The group composition of humus in very humic (rich) chernozems of Northern Kazakhstan. Pochvovedeniye, No. 7.
11. YEMEL'YANOV, I.I. 1956. Composition and properties of organic substances in the soils of Kazakhstan. Trudy Instituta pochvovedeniya Akad. Nauk Kazakhskoy SSR. Vol. 6. Alma-Ata.
12. KONONOVA, M.M. 1951. The problem of soil humus and the current tasks for its study. Izd. Akad. Nauk SSSR. Moscow.
13. KRASNOV, A.N. 1887. Soils of Tyan'-Shan'. Trudy Obshcestva estestvoz naniya pri MGU. Vol. 18.
14. PAVLOV, N.V. 1948. Botanical geography of the USSR. Izd. Akad. Nauk KazSSR. Alma-Ata.
15. PRASOLOV, L.I. 1909. Study of vertical soil zones in the Tyan'-Shan'. Pochvovedeniye, No. 1.
16. Agricultural practices in the Alma-Ata Region. 1958. Kazgosizdat.
17. SOKOLOV, S.I. 1946. Soils of the Lesser Alma-Atinka basin and the danger from mud and rock flows. Izvestiya Akad. Nauk Kazakhskoy SSR. Ser. pochvovedeniye. No. 3. Alma-Ata.
18. CHULAKOV, SH.A. 1954. Distribution of the Azotobacter in the soils of the Trans-Ili Ala-Tau. Mikrobiologiya (23)6.
19. CHULAKOV, SH.A. 1955. Vertical soil zonality and soil microflora. Trudy Instituta pochvovedeniya Akad. Nauk Kazakhskoy SSR. Vol. 5. Alma-Ata.

IATURAL SOIL RADIOACTIVITY AND DETERMINATION OF OTAL POTASSIUM BY A RADIOMETRIC METHOD

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The radioactive series of uranium, thorium, d actinium, as well as rubidium, potassium, rbon and certain other elements are the na- ral radioactive elements of the soil. Accord- g to the data of Vinogradov, Baranov and seytlin, Burkser, and others (1, 2, 3, 4, 6, 15), ils formed on different rocks sharply differ om each other in their radioactivity. Soils igneous rocks are more radioactive than ils on sedimentary rocks. Among the igne- s rocks those that are acid (for instance, anites) are more radioactive than basic cks.

Uranium is one of the common radioactive il elements (its mean content is $1 \times 10^{-4}\%$). s content in a soil profile usually increases ward the parent material. Vinogradov (3) be- eves that uranium is very mobile in a soil lution and forms readily soluble complex com- unds which are leached from the soil. The moval of uranium is most intense in the upper rizons of podzolic and forest soils and in red rths. These soils contain considerably less anium than is contained on the average in e earth's crust.

By contrast to uranium, thorium (its mean ntent in the soil is $6 \times 10^{-4}\%$) has a tendency accumulate in soil horizons rather than in e parent material. The relative accumulation thorium in the upper soil horizons is related the fact that the thorium-bearing minerals thorite and thorionite — do not weather easily.

The mean content of radium in the soil is $x\ 10^{-11}\%$, which is slightly less than in rocks. a rule, the upper horizons of a soil profile ve the highest radium content.

The mean potassium content in the earth's ust is 2.6%, and its radioactive isotope K^{40} nounts to 0.0119% of the natural mixture of iso- pes. Rubidium (whose mean content in the rth's crust is rather high at 0.03%) is natural- radioactive because of the Rb^{87} with soft β- ys. The radioactivity of actinium and cer- n other elements may be neglected in the st approximation, because of the rarity of ese elements.

After a number of determinations of the dioactivity of soils in a B-type assembly with T-25-BFD face counter, as well as an AS-2 uminum counter and an AMM-4 glass counter, we decided to use the aluminum counter. Determinations were made in a layer of soil thicker than the maximum absorption layer, since measurements on thin layers give low counting rates and, in addition, require the use of a correction factor for self-absorption. The determinations were made in a cylindrical carton 11.4 cm high, consisting of two cylinders: the outer, 5.3 cm in diameter and the inner, 2.1 cm in diameter. The outer cylinder with soil put through a sieve with 1 mm opening (about 270 gm, which is 3.6 gm per square centimeter of the inner cylinder). The soil in the cylinder was compacted by light tapping. The aluminum counter was placed into the inner cylinder made of Whatman paper. The determinations were made in a lead enclosed box; the duration of the measurements was not less than 30 minutes, whereby the mean square root counting error did not exceed 5%. Background radioactivity was 32-35 counts/minute. In this manner, soil radioactivity caused primarily by the β-radiation of potassium, uranium, and thorium was taken into account.

In order to show how these three elements affect soil radioactivity under measurement conditions similar to ours, we give the following data (15):

With 1% of K_2O,	25	counts/minute	are	recrd.
With 0.0006% of Th,	5	"	"	"
With 0.0001% of U,	4	"	"	"

Table 1 contains data on the radioactivity of a number of sod-podzolic soils, expressed in counts per minute, obtained by us under experimental conditions. For comparison it also gives data on the radioactivity of individual samples of: chernozems, red earths, sierozem and brown forest soil.

With a uranium content of $1 \times 10^{-5}\%$ in sod-podzolic sandy loam (as determined at the Geological Institute), the number of counts should not be more than one per minute. In this case the other 18 counts are caused by thorium, the content of which in this soil is fairly high, reaching $2 \times 10^{-3}\%$.

Let us consider increased radioactivity in the podzolic and transitional horizons in the profile of soil from Krasnoyarsk Kray.

Table 1

Natural soil radioactivity from β-radiation

Soil	Horizon and depth, cm	Soil radioactivity, cpm[a]				Content, % (chemical method)	
		Total	Including that caused by:		per 1 cm^2 of soil surface	Potassium	Uranium
			K	U and Th			
Sod-podzolic sandy loam. Lyuberetsk experimental field	A_p	28,2±1,4	9,0	19,2	0,4	0,30	1×10^{-5}
Sod-podzolic, coarse clay loam. Kolkhoz "Kolos"	Ap	50,7±1,3	32,0	18,7	0,7	1,07	Not det'd.
Sod-podzolic on red sand-stone. Krasnoyarsk Province.	A_1 0—8	62,4±2,1	42,0	20,4	0,8	1,4	"
	A_2 15—25	66,4±1,9	22,2	44,2	0,9	0,74	
	A_2/B_1 28—34	65,0±1,6	18,3	46,7	0,9	0,61	
	B_2 40—50	60,1±2,0	30,0	30,1	0,8	1,0	
	C 55—65	60,3±2,1	29,7	30,6	0,8	1,99	
Sod-podzolic medium clay loam. Sovkhoz "Stepanovskoye." Moscow Region.	A_2/B_1 20—30	68,6±2,0	44,7	24,9	0,9	1,49	"
Sod-medium-podzolic, medium clay loam. Dolgoprud experimental station.	A_p	69,5±1,8	49,8	19,7	0,9	1,66	2×10^{-5}

Note: Comma represents decimal point.

Table 1 continued

Soil	Horizon and depth, cm	Soil radioactivity, cpm[a]				Content, % (chemical method)	
		Total	Including that caused by:		per 1 cm² of soil surface	Potassium	Uranium
			K	U and Th			
Sod-alluvial. Oka River flood plain.	Ap	62,6±1,4	28,2	34,4	0,8	0,94	Not det'd.
Clay from Moskva River flood plain, Gorkiy Kolkhoz.		104,0±2,7	36,9	67,1	1,4	1,23	"
Thick chernozem of meadow steppe. Kursk national park.	A_1	58,5±1,8	30,0	28,5	0,8	1,00	4 10^{-4}
Highly leached chernozem from the Cis-Caucasus. Rostov Region.	A_2 25—35	55,0±2,0	32,4	22,6	0,7	1,08	Not det'd.
	A_2 35—45	57,0±2,1	35,4	21,6	0,8	1,18	
	B/C 100—120	55,0±2,1	35,1	19,9	0,7	1,17	
	C 140—160	39,6±1,7	25,5	14,1	0,5	0,85	
Brown forest. Amur River basin.	0—7	77,9±2,0	60,0	17,9	1,0	2,04	"
	83—93	83,2±1,6	49,8	33,4	1,1	1,66	
	117—127	82,1±1,9	56,4	25,7	1,1	1,88	
Red earth from Ana seuli.	A_1 0—15	55,9±2,1	33,6	22,3	0,7	1,12	"
Sierozem.[b] Golodnaya Steppe, Mira-Rabat.	0—10	67,6±2,4	37,3	30,3	0,9	1,76	"
	10—20	69,0±1,9	37,1	31,9	"	1,75	
	20—30	66,5±1,5	36,9	29,6	"	1,74	
	40—50	64,4±1,7	32,2	32,2	"	1,52	
	100—110	66,8±1,6	34,0	32,8	"	1,60	

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[a] As measured by us with an aluminum counter.

[b] The radioactivity of sierozem was measured with another, less effective counter.

Note: Comma represents decimal point.

An important role in the radioactivity of soils is apparently played by the radioactivity of the parent material. Therefore, it is hard to agree with the statement of Yastrebov (11), based on the analysis of only one sample from each soil zone, that soil radioactivity is increasing in the European USSR from the north to the south. In our investigations chernozem from Kursk, greatly leached chernozem from the Cis-Caucasus and red earth from Anaseuli had a similar radioactivity of 55-59 counts/minute. But their radioactivity was lower than that of the soils from the Dolgoprud experimental station and from Stepanovskoye sovkhoz, located in a more northern zone.

The high radioactivity of clay from the Moskva River flood plain (Gor'kiy kolkhoz) amounting to 104 counts/minute is quite conspicuous. With a relatively low potassium content (1.23%) in this clay, other radioactive elements account for 67 counts/minute, that is, slightly higher than in sod-podzolic soils. This is possibly associated with the higher adsorption capacity of clay with respect to uranium and thorium.

Radioactivity of the soils investigated by us varies from 28-83 counts/minute. The ratio between the counts caused by uranium and thorium also varied in various soils as well as within the profile of one and the same soil. In 15 out of 25 cases potassium accounted for more counts than uranium and thorium (the difference ranged from 5 to 42 counts/minute); in five cases the number of counts was distributed evenly between K and U + Th; and, finally, in five cases U + Th accounted for more counts than K^{40}. Thus, when determining total soil radioactivity, it is impossible to tell by what specific element it is caused. But knowing the content and activity of soil potassium, it is possible to estimate the amount of U + Th in a soil from the radioactivity of the soil.

To provide a better idea of the quantitative radioactivity of the soils studied, Table 1 also gives the measured radioactivity converted to 1 cm² fluctuates between 0.4-1.1 counts/minute. When a face counter is used, which also records the softer β-rays, the number of counts per 1 cm² of soil surface is two times greater than when an aluminum counter is used. It may conditionally be assumed that the radioactivity of about 1-2 counts/minute per 1 cm² of soil surface (not counting α-particles and γ-rays) is precisely that activity which affects the roots of plants. When the total surface of the roots, for example, those of spring wheat, is 3-5 m², irradiation by β-particles of the root system of a single plant would be 60-100 thousand counts/minute.

Determination of the Total Potassium Content by a Radiometric Method

The possibility of determining potassium radiometrically is based on the fact that potassium in soil, in various salts, in rocks, etc., has a constant isotopic composition. Potassium in natural and chemical compounds consists of the K^{39} (93.08% in the isotopic composition), K^{40} (0.0119%), and K^{41} (6.91%) isotopes. The half-life of the K^{40} isotope is $T = 1.25 \times 10^9$ years.

An attempt to determine radiometrically the content of potassium in its salts had already been made in 1941. Since then considerable progress has been made in the radiometric determination of potassium. The maximum adsorption layer for potassium salts has been found (13, 14) to be 0.6 g/cm² when converted to β-rays. A direct relationship has been established between the potassium content in the salt and the counting rate under the same conditions. A number of works (7, 8, 9, 10, 12, 16) describe ways of determining by this method the percentage of potassium contained not only in pure, but also in raw potassium salts, in industry and mines.

During our initial work on the radiometric determination of potassium in the soil we were faced with the problem that our AS-2 type counter was recording not only K^{40} but also other radioactive elements contained in the soil. The number of counts from U + Th varies in different soils. In order to distinguish the counts from K^{40} and to uranium with thorium in the soils studied, the following method of determining potassium in the soil was worked out: a cylindrical shield of brass foil, 0.15 mm thick, was used, which preferentially screens radiation from potassium and to a lesser degree that from U + Th, because of the different energy of β-radiation from potassium and U + Th. This allows one to measure individually the radioactivity of potassium and that of U + Th.

Using potassium chloride, consisting of a mixture of NaCl and KCl (11.2% of K), for calibration, we established that when the shield was used only 19.4% of the counts, measured under the same conditions but without the shield, was counted. A similar measurement (with and without the shield) of a mixture of NaCl with acetic uranyl (0.0082% of uranium) 35.8% was obtained for uranium. The β-rays of U and Th have approximately the same penetration ability (7).

By using these coefficients (19.4% and 35.8%) and measuring radioactivity with and without the screen, two equations with two unknowns may be obtained for each soil. For example, for soil from Lyuberetsk:

without the shield: 28.2 counts/minute = K + U (Th)
with the shield: 8.2 counts/minute = 0.194 K + 0.358 U (Th),

where K + U (Th) is the number of counts per minute caused by K and (U + Th).

After finding from these equations the number of counts per minute caused by potassium we determine the total potassium content in the soil from the standard straight line. In plotting the standard straight line we use the method of additions. Different amounts of pulverized, chemically pure KCl were added to a soil poor in total potassium, the largest addition not exceeding 3% of potassium by soil weight (the maximum potassium content in natural soil). After thorough mixing, each soil sample was placed in the cylindrical container described previously and its activity was measured in counts per minute as an average of 30 minutes

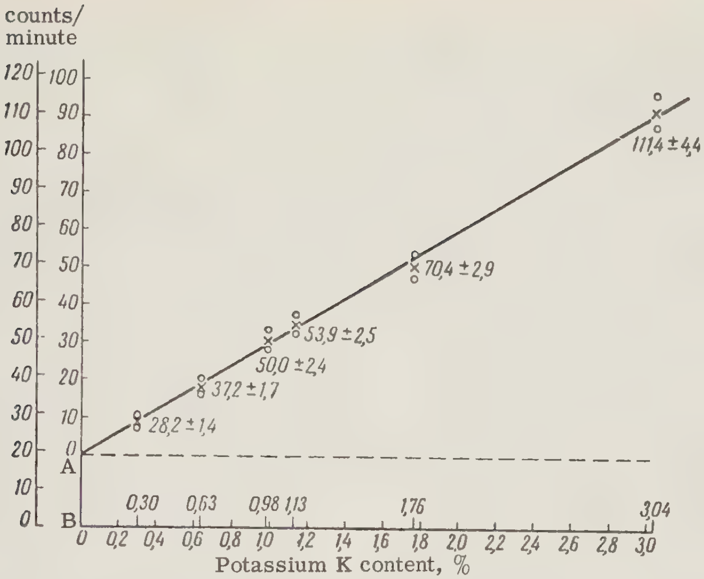

Fig. 1. - The standard curve of the potassium content in the soil, %

measurements. The data were then plotted a graph with the number of counts per min- e on the ordinate and the percentage of potas- im (including addition) in the soil on the ab- issa (Fig. 1).

As may be seen on Figure 1, the straight e drawn through the experimental points cut the section A-B on the ordinate, showing the mber of counts per minute caused by uranium d thorium in the given soil. To determine tassium in any other soil from this graph, e number of counts per minute from potas- im must first be found from the foregoing uation and then the percentage of potassium rresponding to this number of counts per nute can be found from the graph. For ex- ple, in the thick chernozem from the Kursk gion, 33.6 counts/minute were from potas- im. By finding this value on the right hand scale of counts per minute (see Figure 1) we ain 1.12% as the amount of potassium in this l.

Sod-podzolic, chernozem, brown forest l and sierozem were used for comparative erminations of potassium by the proposed diometric method and by a chemical method. ble 2 gives the data obtained from these mparative determinations. The chemical ermination of potassium was made by first ating the soil with hydrofluoric acid and n by determining potassium in a flame otometer.

For six out of ten soil samples (Table 2) the sults obtained radiometrically were higher 0.08%-0.24% and for four others lower by 1%-0.11% than those obtained by chemical lysis.

The results of M. Gurskiy's study show a 0.01%-0.45% deviation in the amount of total potassium determined radiometrically from that determined chemically. However, during this study no correction factor was used for uranium and thorium in each individual soil sample. The deviations of the results of the radiometric method from those of the chemical method are due to the inaccurate determination of the adsorption coefficients for potassium and uranium. Since the accuracy in determining radioactivity depends on the number of counts, the use of a shield considerably increases the error. In our experiments measurements with the shield lasted not less than an hour and still the error amounted to 4%-12%. Lowering background radiation and increasing of the number of counts for a sample should increase the accuracy of the determination. The accuracy of the method could probably be also increased by selecting a more appropriate shield.

It is quite possible that in the future, when dealing with the plowed horizon of soils belonging to the same group and having the same texture, the amount of U + Th could be assumed as being the same. Then knowing the number of counts per minute from U (Th) in one sample, all other samples could be measured without shield. Kovalevskiy (7) has suggested that the ratio between the radioactivity of a sample produced by β-rays and α-rays should be used for radiometrically determining potassium in minerals containing uranium and thorium. It is possible that this method could also be used for soils.

Since all chemical methods of determining total potassium in the soil are very laborious and time-consuming, the radiometric method has a lot to offer. It is a simple, rapid and accurate method (in the sense that it involves

Table 2

Radiometric and chemical determination of potassium in the soil

Soil	Horizon and depth, cm	Soil radioactivity, cpm (during counting)		Potassium K content in soil,%		Difference between I and II	Difference in % from chemical determination
		Without shield	With shield	I radiometric determination	II chemical determination		
Sod-podzolic, sandy loam. Lyuberetsk experimental field.	A_p	28,2±1,4	8,2±1,0	0,38	0,30±0,03	+0,08	26,7
Sod-medium podzolic, medium clay loam. Dolgoprud experimental station.	A_p	69,5±1,8	16,2±1,6	1,78	1,66±0,00	+0,12	7,2
Sod-illuvial. Oka River flood plain.	A_p	62,6±1,4	16,7±0,9	1,18	0,94±0,01	+0,24	25,7
Thick chernozem of meadow steppe. Kursk national park.	A_1	58,5±1,8	15,5±1,2	1,12	1,00±0,09	+0,12	12,0
Brown forest. Amur River basin.	0—7 83—93	77,9±2,0 83,2±1,6	18,2±1,0 22,1±0,9	2,00 1,59	2,04±0,02 1,66±0,03	—0,04 —0,07	2,0 4,2
Sierozem. Golodnaya Steppe. Mira-Rabat.	0—10 10—20 20—30 100—110	67,6±2,4 69,0±1,9 66,5±1,5 66,8±1,6	17,7±1,2 17,6±0,9 17,1±1,1 17,2±1,0	1,65 1,80 1,73 1,73	1,76±0,03 1,75±0,06 1,74±0,02 1,60±0,01	—0,11 +0,05 —0,01 +0,13	6,2 2,8 0,6 8,1

Remarks: For the first five soil samples potassium was calculated from the standard curve (Fig. 1); for sierozem a different curve was used because its radioactivity was measured with a counter of different effectiveness.

Note: Comma represents decimal point.

large soil sample). In addition, the entire
il sample is saved.

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BIBLIOGRAPHY

BARANOV, V. I., and S. G. TREYTLIN. 1941. The content of radioactive elements in some soils in the USSR. Doklady Akad. Nauk SSSR. (30)4.

BURKSER, YE. S. 1954. How the age of rocks is determined. Izd. Akad. Nauk USSR Kiev.

VINOGRADOV, A. P. 1950. Geochemistry of rare and scattered elements in the soil. Izd. Akad. Nauk SSR.

VINOGRADOV, A. P. 1954. Searching for ore deposits by studying plants and soils. Trudy biokhimicheskoy laboratorii Vol. 10.

VOLKOV, I. K. 1951. The root system of spring wheat under irrigation conditions in the Central chernozem zone of the RSFSR. Doklady Akad. Nauk SSSR. (77)1.

DROBKOV, A. A. 1952. Natural radioactive elements and their biological role. In the book: Mikroelementy v zhizni rasteniy i zhivotnykh. Izd. Akad. Nauk SSSR.

KOVALEVSKIY, A. 1957. Improvement of the radiometric method of determining potassium in powdered samples. Ministerstvo geologii i okhrany nedr SSSR. Sbornik nauchnotekhnicheskoy informatsii. No. 5.

KORENMAN, I. M., and YE. I. ZORIN. 1955. Radiometric determination of potassium Zavedskaya laboratoriya. No. 12.

9. POLEVAYA, N. I., and V. A. MIKHAYLOVA. 1956. A rapid method of quantitatively determining potassium in salt-bearing sedimentary rocks. Materialy Vses. n.-i. geol. in-ta VSEGEI. Nov. seriya. No. 1. Materialy po litologii. Gosgeoltekhizdat.

10. SHPAK, V. A., and P. I. NOVIKOV. 1954. Use of the properties of the radioactive isotope of potassium for determining the percentage of potassium in samples, or directly in rocks. Khimicheskaya promyshlennosti. No. 3.

11. YASTREBOV, M. T. 1958. Natural radioactivity of zonal soils in the European USSR. Doklady Akad. Nauk SSSR. (119)3.

12. GAUDIN, A. M., and J. H. PANNELL. 1948. Radioactive Determination of Potassium in Solids. Anal. Chem. 20 (12).

13. GÜBELI, O., and K. STAMMBACH. 1951. Zur quantitativen Analyse Kaliumhaltiger Salze und Lösungen auf Grund ihrer natürlichen Radioaktivität. Helv. Chim. Acta. 34 (1245).

14. HALAUNUBRENNER, J. 1954. O promieniowaniu soli potasowych. Roczn. chem. 28 (4).

15. LIBBS, H. S., and G. J. McCALLUM. 1956. Natural radioactivity of soils. N. Z. J. Sci. and Technol. Vol. 37, 354-368.

16. SCHEEL, K. 1954. Schnellbestimmung des Kaliums in Kalisalzen durch Strahlungsmessung. Angew. Chemie. 66 (4).

CHARACTERISTICS OF THE EXCHANGE OF MINERAL ELEMENTS BETWEEN MOSS-LICHEN-SHRUB VEGETATION AND SOIL IN TWO TYPES OF PINE FOREST IN THE KOLA PENINSULA

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The problem of the exchange of substances between the soil and vegetation has been the subject of many studies. The results of studies during early phases of soil formation have been reported by Polynov (13) and his collaborators, Yarilova (21), Assing (2), and Bobritskaya (4). The exchange cycle of substances in forest stands has been treated by Ebermayer (22), Remezov, Smirnova and Bykova (16), Smirnova (18), Dzens-Litovskaya (6), Troitskiy (20), Mina (12), and others. The exchange of mineral elements between the soil and cultivated crops was described by Bobritskaya (5). The articles of Kovda (8) and Bazilevich (3) have a more general character. All these studies refer to the central or southern parts of the Soviet Union. Only recently did an article by Rozhnova and Schastnaya (17) appear which was devoted to the study of the interrelation between vegetation and the soils of the isthmus of Karelia.

This article deals with the problem of the exchange of mineral elements between podzolic soils and moss-lichen-shrub vegetation in the northern subzone of the thinly scattered taiga of the Kola Peninsula. The study was conducted between 1947 and 1949 on the initiative and under the leadership of I. V. Tyurin.

Our observations were made on two plots with natural vegetation and one plot with cultivated soil cropped to oat, timothy and clover.

Plot No. 1 occupies a flat summit and the upper and middle parts of the slopes of a sandy loam moraine ridge containing a very large amount of boulders. Vegetation consists of a thin pine stand with an undergrowth of lichens. Cladonia alpestris and Cladonia rangiferina predominate, covering 80%-90% of the area. Small patches of Polytrichum and other mosses are found among the lichens. The underbrush consists of thinly scattered crowberry, whortleberry and cranberry. The soil developing under this vegetation is an iron podzol, characterized by a shallow soil profile and a yellow-ochre illuvial horizon (A_0 0-1 cm, A_2 1-2 cm, B 4-22 cm, BC 22-46 cm, C 46-90 cm).

Plot No. 2 is located near a bog and occupies the gentle slope of a sandy loam moraine ridge, containing a very large amount of boulders. Vegetation is represented by a slightly-bog spruce-birch-pine green-moss forest. Pleurozium schreberi predominates. There are also some lichens. The underbrush consists primarily of blueberry, whortleberry, crowberry and ledum. Closer to the bog there are patches of sphagnum and dwarf-birch thickets. Herbaceous vegetation is found in places in the form of hair grass and goldenrod. The soils are predominately humic podzols with a deeper profile and a dark-coffee colored illuvial horizon. (A_0 0-6 cm, A_2 6-20 cm, B 20-36 cm, B_2 36-50 cm, BC 50-86 cm, C 86-150 cm). Ground water is found from a depth of 95 cm.

Plot No. 3 is located in the area of the Arctic experimental station of VIR (All-Union Plant Institute) (Khibiny station, on the other side of the lake). The soil is a cultivated humic-iron podzol. Oat, timothy and second-year clover were taken for study. Total chemical analyses of the foregoing soils are shown in Table 1.

Forest vegetation was studied (tops and roots and samples were taken for analysis at the end of July and the beginning of August, while cultivated crops were studied and sampled during the harvest period. Plant tops were sampled from 1 m² and replicated 6 times. The mass of roots was assessed according to the method of Kachinskiy (7). The mass of forest litter in the A_0', A_0'' and A_0''' layers was replicated four times from an area 50 x 50 cm. The mass of annual litter fall (from trees and bushes) was determined in plots 1 m². The amount of dying-off lichens and mosses was determined by assuming it to be equal to annual growth; observations were made on growth. The methods of investigation are described in more detail in another article which is being published (11). The ash content in plants was analyzed using Aleksandrova's method (1).

Experimental

Green-moss and white-moss pine forests hav approximately the same vegetative mass per uni area, equal to about 45 cntr/ha of dry matter. However, they differ greatly in the composition of plant species. The first consists primarily of small shrubs (whortleberry, blueberry, cranberry, and ledum, which comprise 82% of the total vegetation) and green masses (9.5% of the total vegetation). The latter is almost entierly represented by the bushy lichens Cladonia

Total chemical analysis of iron, humic and cultivated-humic-iron podzols

Profile No.	Soil	Horizon	Depth, cm	In % of weight of ignited soil											
				SiO_2	Al_2O_3	Fe_2O_3	MnO	CaO	MgO	P_2O_5	SO_3	K_2O	K_2O+Na_2O	Na_2O	Total
1	Iron podzol	A_2	1—3	79,46	12,70	1,44	0,009	2,43	0,44	0,014	0,05	—	3,45	—	99,993
		B	4—14	70,77	17,16	4,77	0,054	3,15	0,90	0,098	0,08	—	4,47	—	101,452
		BC	35—45	73,60	15,08	3,58	0,068	3,28	0,94	0,067	0,06	—	4,75	—	101,425
		C	50—60	71,92	14,60	3,38	0,074	3,29	0,68	0,062	0,06	—	5,51	—	99,576
5	Humic podzol	A_2	9—14	78,40	12,20	1,64	0,02	2,47	0,61	0,030	0,034	1,48	—	3,54	100,424
		B_1	22—30	70,54	16,90	3,94	0,05	3,12	0,87	0,11	0,116	1,48	—	4,08	101,206
		B_2	38—46	72,30	14,50	3,40	0,07	3,31	0,93	0,08	0,07	1,43	—	4,31	100,400
		BC	65—73	73,26	14,66	2,70	0,07	3,39	0,99	0,08	0,07	—	—	—	95,22
		C	102—110	73,80	14,80	2,54	0,07	3,45	0,77	0,07	0,06	—	—	—	95,56
	Cultivated humic-iron-podzol	A plowed	0—10	61,72	16,37	6,66	0,83	4,60	3,13	0,21	Trace	—	—	—	93,52

Note: Comma represents decimal point.

alpestris and *Cladonia rangiferina*.

The natural vegetation of the Kola Peninsula is characterized by its low ash content. According to our data, the raw ash content in whortleberry (tops) is 2.46% of the absolutely dry substance; that in cranberry is 2.55%; in crowberry, 1.63%; in ledum, 1.36%; blueberry, 1.36%; and in the green moss, somewhat more than 3.77%. Bushy lichens have the lowest ash content (less than 1%). The difference in plant species growing on iron and humic podzols determines the difference in the chemical composition of ash. This difference is especially pronounced in the tops and less pronounced in the roots. As Table 2 shows, vegetation growing on iron podzols contains almost ten times more silicic acid than vegetation growing on the humic podzol. The reason for this is that bushy lichens, which predominate on iron podzol, possess a high degree of selectivity with respect to SiO_2. Kursanov and D'yachkov (10), who studied the lichens of the Kola Peninsula, found that the ash of some of the lichen species contained as much as 84% silicic acid. This is attributed by these investigators to the participation of silicic acid in the composition of several organic substances, such as lichenin and related polysaccharides, in which SiO_2 amounts to 2.64%.

The tops of humic podzol vegetation and the roots of the vegetation growing on both types of podzol do not contain much SiO_2.

On the other hand, the tops of vegetation on humic podzol contains 2.5 times more Al_2O_3 than that of iron podzol. This is due to the fact that humic podzol is more moist, so that AlO_2 is more readily available to plants. This is corroborated by studies made by Stoklasa (23), who established that moisture-loving plants, and especially their roots, contain much aluminum.

The large amount of aluminum and, partly, iron in roots from the A_2 and B horizons of both pdozols may be explained, in our opinion, not only by the selectivity of plant root systems with respect to these elements, but also partly by the fact that when sesquioxides precipitate in the soil in the form of organo-mineral compounds they coat the root masses with a thin film. It is almost impossible to remove this film when preparing samples for analysis and it dissolves into a solution of weak hydrochloric acid together with elements of pure ash. This is why the sesquioxide content in the ash of roots from the mineral horizons of both soils might be too high.

It is interesting to note that the concentration of manganese in the ash of the vegetative tops of humic podzol and in that of the roots from the A_0 horizon of both soils is relatively high. It appears that certain species of shrubs, but not lichens, have the ability to accumulate manganese. This is confirmed by data in Table 2, which show that the ash of the vegetative tops of iron podzol contains almost five times less manganese than the ash of the vegetation of humic podzol. Approximately the same is true of calcium and magnesium. The vegetative tops of iron podzol contains very little calcium and magnesium. Considerably more calcium and magnesium accumulates in the vegetative tops of humic podzol, as well as in the roots from the forest litter horizon of both podzols. The

Table 2

Chemical composition of ash in natural and cultivated vegetation

Sample	Vege. moss (completely dry, cntr/ha)	Pure non-carbonate ash, % of completely dry vegetative moss	In % of pure non-carbonate ash								
			SiO_2	Al_2O_3	Fe_2O_3	MnO	CaO	MgO	P_2O_5	SO_3	Total
					Iron podzol						
Vegetation[a] (tops)	40,70	0,82	48,79	4,01	6,57	1,39	7,44	3,90	10,54	4,18	87,82
Roots, A_0 horizon	12,44	1,09	4,10	11,79	3,63	7,35	30,18	9,92	13,27	6,94	87,18
" A_2 "	6,01	1,79	19,05	27,29	10,90	1,28	12,00	8,85	11,71	5,60	96,68
" B "	15,82	1,99	14,85	40,24	6,05	Trace	12,99	7,44	8,22	3,88	93,67
Tops + roots, A_0[b] horizon	—	—	35,88	6,25	5,72	3,11	14,22	5,64	11,32	4,97	—
					Humic podzol						
Vegetation (tops)	43,57	1,68	5,08	10,23	2,22	6,45	28,4	10,51	11,45	8,60	82,94
Roots, A_0 horizon	14,00	0,82	3,27	7,53	4,85	9,55	19,55	11,21	13,02	7,86	76,84
" A_2 "	11,16	2,08	6,77	32,83	35,18	0,11	6,32	4,19	7,09	3,61	96,10
" B "	5,03	2,82	5,69	54,42	22,15	0,14	6,47	3,76	4,03	2,15	98,81
Tops + roots, A_0 horizon	—	—	3,97	8,54	3,53	8,34	22,73	10,93	12,30	8,09	—
					Cultivated iron-humic podzol						
Oat (Tops	45,00	6,09	23,16	0,49	0,31	0,31	4,15	1,96	5,66	4,0	40,04
Oat (Roots, A-plowed	27,30	4,76	25,09	10,04	3,82	0,72	6,69	2,59	5,96	7,56	62,47
Oat (Tops + roots, A-plowed[b]	—	—	23,78	3,56	1,43	0,44	4,96	2,16	3,68	5,14	—
Timothy 2 years old (Tops	72,00	3,78	29,15	0,39	0,85	0,28	4,32	2,14	6,93	5,75	49,81
Timothy 2 years old (Roots, A-plowed	37,60	2,63	32,82	13,70	4,61	0,23	9,81	2,29	6,47	4,65	74,58
Timothy 2 years old (Tops + roots, A-plowed	—	—	30,39	3,93	1,85	0,26	5,78	2,17	6,80	4,29	—
Clover 2 years old (Tops	44,20	7,46	3,33	1,86	1,00	0,37	40,02	6,80	5,44	1,75	60,57
Clover 2 years old (Roots, A-plowed	41,70	3,49	25,28	5,80	1,54	0,18	8,83	11,88	5,00	12,64	71,15
Clover 2 years old (Tops, + roots, A-plowed	—	—	10,05	3,06	1,16	0,31	30,46	8,35	5,30	5,08	—

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[a] The term "vegetation," as used in this article, refers to the moss-lichen cover and shrubs. Trees are not included.

[b] The data for "tops + roots, A_0 and A-plowed, were obtained by calculation and not directly.

Note: Comma represents decimal point.

lcium content in the ash of the vegetation of th soils is two to three times higher than that magnesium. As far as P_2O_5 and SO_3 are ncerned, there is no noticeable difference in eir content, which is high in the vegetation of th podzols.

In order to compare the ash composition of tural vegetation with that of crops such as ts, timothy and clover, growing on the culti- ted humic-iron podzol, were analyzed. Table shows that the ash of oat and timothy has a gh content of silicic acid, sulfur, phosphorus d calcium, whereby roots contain more cal- um than the plant tops. The ash of roots has high content of aluminum and iron. The over tops have a very high content of calcium d a low content of silicic acid, while its roots ntain a large amount of sulfur and magnesium. s compared to cultivated crops, natural vege- tion has a lower percentage of ash with a gher content of aluminum, iron and manganese. e Ca and Mg contents in oats and timothy are t high.

In comparing our results with the data ob- ined by Rozhnova and Schastnaya (17) for milar vegetation in the isthmus of Karelia osses, lichens and whortleberry), we may te that the vegetation of iron podzol of the la Peninsula has two times less ash, but the mposition of the ash is similar to that of the h of Cladonia alpestris growing on granite in e isthmus of Karelia. The most significant fference between them is in their potassium ntent, which may be explained by the richness the parent material in this element.

It is difficult to compare the combined moss d brush vegetation with individual plant spe- es (whortleberry, mosses), however, it ap- ars quite certain that the ash content of vege- tion varies depending on conditions of plant owth. The ash content of whortleberry (prob- ly growing under similar conditions) is the me, while that of moss is considerably higher the isthmus of Karelia, probably because of higher mineralization of soil water. In addi- n, our belief that certain shrubs, in particu- r whortleberry, possess a selective ability th respect to manganese and that mosses have, parently, the highest sesquioxide content, is ing substantiated.

Comparison of these data indicates that the re northern vegetation of the Kola Peninsula nds to have a higher concentration of man- nese, aluminum and iron. The accumulation of uminum and iron in vegetation promotes humic- uvial soil development, while the accumulation manganese apparently plays an important part the decomposition (oxidation) of plant residues.

In comparing our results with data provided by nomareva and Mysnikova (15) for herbaceous getation of spruce forests on leached sod-car- nate soil in the southern taiga zone, we may te that the moss-shrub vegetation of the green- ss pine forest of the northern taiga zone con- ns four to five times less ash but more ses- ioxides, especially aluminum and manganese. e same holds true for the ash composition of alis growing in green-moss spruce forests on arse clay loam podzol in the Velikiye Luki gion (18).

In comparing our data for cultivated crops with those of Bobritskaya's (5) for timothy and clover on cultivated sod moderately-podzolic soil in the Moscow Region, we should note that timothy and clover in the Kola Peninsula have a smaller percentage of pure ash. Their tops have a very similar chemical ash composition, except that the clover in the Kola Peninsula has a little more aluminum and iron and less sulfur, while timothy contains more silicic acid and less potassium, magnesium and sulfur. The roots of clover and timothy in the Kola Peninsula contain more silicic acid, aluminum and iron and less sulfur than those of clover and timothy in the Moscow Region, the difference being more pronounced than in the shoot of the plants.

We used Polynov's (13) method for characterizing the relative uptake of mineral elements by plants, and constructed biological uptake series.

For the conditions studied, which are characterized by a sharp separation of the soil profile into genetic horizons which are completely different in their chemical composition, we set up a biological uptake series for each horizon individually (A_0, A_2 and B). We constructed general biological uptake series for the tops of mixed vegetation and root masses in the forest litter horizon only, excluding the roots from the A_2 and B_1 horizons because of their possible contamination with aluminum and iron. We also constructed separate uptake series for plant tops in the A_0 horizon in order to determine the characteristics of uptake of elements by vegetation in which the rootless lichens and mosses predominate. For cultivated crops, the uptake series were constructed for the plowed horizon.

Since the method of compiling biological uptake series has been already described in the literature (15, 20), we will not discuss it here. Table 2 gives data on the ash composition of plants, while Table 1 provides information on the total chemical composition of mineral soil horizons (A_2, B and A-plowed). The ash composition of forest litter (A_0'') is given in Table 3.

Biological uptake series for humic podzol vegetation in the A_2 and B horizons are very similar, in spite of the fact that these horizons differ greatly in their total chemical composition. The order of elements in both is the same. Both series show a very high uptake of manganese, phosphorus and sulfur by vegetation, sharply differing from that of other elements. These three elements are followed first by magnesium and then by calcium. Iron, aluminum and silicon are taken up with the least intensity, their uptake factor being less than one. The only difference between these two series is that the A_2 horizon has much higher uptake factors than the B horizon because of its relative paucity in all elements. In both series silicon is taken up least intensively of the latter three elements. A somewhat different picture is presented by the relative biological uptake of the forest litter horizon. Here the group of elements which are taken up intensively includes magnesium, manganese, calcium, sulfur and phosphorus; the group of weakly absorbed elements consists of aluminum, iron and silicon. The uptake factors for these series are characteristically low and similar to each other. In addition, magnesium, stands in first place, while the uptake of calcium

Biological Uptake Series

		Humic podzol As compared to the A_0 horizon							
Tops of mixed vegetation		Mg 3,0	Mn 2,9	Ca 2,5	S 2,34	P 1,7	Al 0,6	Fe 0,2	Si 0,1
Tops of mixed vegetation + roots from the A_0 horizon		Mg 3,9	Mn 3,8	S 2,2	Ca 1,9	P 1,8	Al 0,5	Fe 0,3	Si 0,1
		As compared to the A_2 horizon							
Tops of mixed vegetation + roots from the A_0 horizon		Mn 417,0	P 410,0	S 238,0	Mg 17,8	Ca 9,2	Fe 2,1	Al 0,7	Si 0,1
		As compared to the B horizon							
Tops of mixed vegetation + roots from the A_0 horizon		Mn 166,8	111,8	S 69,0	Mg 12,5	Ca 7,2	Fe 0,9	Al 0,5	Si 0,1
		Iron podzol As compared to the A_0 horizon							
Tops of mixed vegetation		P 1,6	Si 1,6	Mn 1,6	S 1,1	Mg 1,0	Fe 0,8	Ca 0,4	Al 0,2
Tops of mixed vegetation + roots from the A_0 horizon		Mn 3,5	P 2,4	Mg 1,8	S 1,7	Si 1,2	Ca 0,7	Fe 0,7	Al 0,4
		As compared to the A_2 horizon							
Tops of mixed vegetation + roots from the A_0 horizon		P 808,0	Mn 345,5	S 99,4	Mg 12,8	Ca 5,8	Fe 4,0	Al 0,5	S 0,4
		As compared to the B horizon							
Tops of mixed vegetation + roots from the A_0 horizon		P 115,5	S 62,1	Mn 57,6	Mg 6,2	Ca 4,5	Fe 1,2	Si 0,5	Al 0,4
		Cultivated humic-iron podzol							
Oat (during harvesting for hay)	Tops	S	P 26,4	Ca 0,9	Mg 0,6	Si 0,37	Mn 0,37	Fe 0,05	Al 0,03
	Roots	S	P 28,3	Ca 1,4	Mn 0,8	Mg 0,8	Al 0,6	Fe 0,6	Si 0,4
	Tops + roots	S	P 27,0	Ca 1,1	Mg 0,7	Mn 0,5	Si 0,4	Al 0,2	Fe 0,2
Timothy (2 years old)	Tops	S	P 33,0	Ca 0,94	Mg 0,7	Si 0,5	Mn 0,3	Fe 0,1	Al 0,02
	Roots	S	P 30,8	Ca 2,1	Al 0,8	Mg 0,7	Fe 0,6	Si 0,5	Mn 0,3
	Tops + roots	S	P 32,3	Ca 1,2	Mg 0,7	Si 0,4	Mn 0,3	Fe 0,3	Al 0,2
Clover (2 years old) (during harvesting for hay)	Tops	S	P 25,9	Ca 8,7	Mg 2,2	Mn 0,4	Fe 0,1	Al 0,1	Si 0,05
	Roots	S	P 23,8	Mg 3,8	Ca 1,9	Si 0,4	Al 0,3	Fe 0.2	Mn 0,2
	Tops + roots	S	P 25,2	Ca 6,6	Mg 2,7	Mn 0,4	Al 0,2	Fe 1,2	Si 0,2

Note: Comma represents decimal point.

Table 3

Chemical composition of ash of plant residue on iron and humic podzols

Sample	Mass of completely dry matter, cntr/ha	Pure ash in the dry matter, %	In % of pure ash								
			SiO_2	Al_2O_3	Fe_2O_3	MnO	CaO	MgO	P_2O_5	SO_3	Total
Iron podzol											
Semi-decomposed litter A_0'	20,24	1,25	17,32	12,70	8,22	2,79	28,51	5,21	10,39	4,49	89,63
Forest litter A_0''	325,00	2,06	30,19	17,28	8,36	0,89	20,22	3,82	6,43	3,65	90,84
Humic podzol											
Fresh litter	8,63	1,68	9,40	5,16	1,62	4,30	39,14	12,60	10,26	7,01	89,49
Semi-decomposed litter A_0'	41,39	2,01	12,71	9,32	8,18	2,61	37,60	8,09	7,97	5,95	92,23
Forest litter A_0''	534,26	2,89	37,38	15,78	11,83	2,20	11,43	3,53	6,88	3,67	92,70

Note: Comma represents decimal point.

is higher than that of phosphorus and sulfur (for plant tops).

The biological uptake series of the A_2 and B horizons for iron podzol vegetation are also similar to each other and, to a certain extent, analagous to those for humic podzol. The vegetation of iron podzol is characterized by a higher uptake of silicon and iron and a less intense uptake of manganese as compared to humic podzol. Uptake series for the forest litter differ sharply from those of the A_2 and B_1 horizons and from analogous series for the vegetation of humic podzol. The outstanding feature here is the fact that silica is among the group of elements intensively absorbed. It stands in second place in the uptake series for the tops of mixed vegetation on iron podzol, rather than in last place as in the case of humic podzol, while calcium belongs to the group of elements which are poorly absorbed, with an uptake factor of less than one. The uptake of magnesium in the A_0 horizon is also less intensive than in humic podzol.

The differences between the biological uptake series for the organogenic forest litter horizon and for the mineral A_2 and B horizons of both types of podzol may be explained by the fact that the ash composition of forest litter differs greatly from the total chemical composition of the mineral horizons.

We paid attention to the uptake of elements by vegetation from the forest litter, since in a series of soils where the A_0 horizon is fairly thick, the exchange of mineral elements between this horizon and vegetation becomes a very important factor. For example, in humic podzol, where almost 90% of all roots is concentrated in the A_0 horizon, the uptake of elements by plants occurs primarily from the forest litter. The tops of vegetation which consists chiefly of bushy lichens having no roots absorb mineral elements on iron podzol exclusively from the forest litter horizon (not counting the atmosphere). The specific uptake of elements by vegetation on humic and iron podzol, is most clearly defined precisely in these series. Because of the difference in the nature of biological uptake series between the vegetation on iron and humic podzol, as referred to the forest litter horizon, we can also talk about the difference played by vegetation in the process of soil formation as far as the exchange of mineral elements between the soil and vegetation is concerned. Vegetation, consisting mostly of bushy lichens, on iron podzol promotes the accumulation in the soil of much silicic acid, little magnesium and no calcium. Vegetation, consisting mostly of shrubs and only partially of green moss, promotes the accumulation of both calcium and magnesium on humic podzol. It follows that in this respect lichens contribute more to the podzol-forming process than shrubs.

Cultivated plants take up sulfur and phosphorus most intensively, then calcium and magnesium, while the uptake of iron, aluminum and silicium is very weak.

The highest concentration of calcium is found in the clover tops while its roots take up more magnesium than calcium. Oat and timothy accumulate calcium to a much lesser degree than does clover. The uptake factor for calcium and magnesium for their tops is even less than one, which may be explained by the high content of calcium and magnesium in the plowed horizon (Table 1). However, in the exchange of mineral elements, the cycle of these elements must be taken into account, i. e., their annual uptake of the elements by plants and their return to the soil in unit area. Since the annual growth of cultivated plants is much greater than that of natural vegetation, and also since their ash content is higher, their uptake of mineral elements is several tens of times higher than that of natural vegetation. However, a considerable portion of the tops of cultivated plants is removed during harvest and thus not returned to soil.

Another significant moment in the exchange of mineral elements between the soil and vegetation is the leaching of these elements from plant residue during its decomposition.

The process of removal of mineral elements from plant residue has been studied for many years by many investigators. They tried to establish, on the basis of experimental investigations, the principles of the removal of mineral elements during their decomposition. So far, the most valuable studies in this respect were made by Kravkov (9), and Stepanov (19). It would be sufficient to note that the method used by Polynov (13), i. e., comparative studies of plant residue mineralized to varying degrees, comes closest to natural conditions.

An attempt was made by us to compile leaching series (Table 3) on the basis of an ash analysis of fresh litter-fall and various parts of the forest litter horizon (A_0' and A_0''). We compiled the leaching series according to the ratio between the content of various elements in the ash from the upper and lower layers of the forest litter. The elements are listed, from left to right, in order of the declining value of this ratio.

The leaching series show that during the decomposition of plant residue the following elements are leached most intensively: Ca, Mg, S, P, Mn. Among them calcium and magnesium are removed most intensively. The group of slightly leached elements consists of Al, Fe, and Si. Because of insufficient factual data, it was difficult to make more detailed conclusions on the removal of mineral elements during the decomposition of plant residue. Our conclusions do not contradict those made by Troitskiy (20) and Rozhnova and Schastnaya (17), and the data obtained by Kravkov (9).

Vegetation is a powerful biological factor in the accumulation of mineral elements in the soil profile, in spite of intensive leaching and accompanying removal of mineral elements from the upper soil horizons. In the types of forests studied, where various types of podzol form, the biological accumulation of mineral elements is more pronounced in the forest litter horizon. It is very difficult to determine the biological accumulation of ash elements in the A_2 and B horizons without special investigations. The accumulation of ash elements in the forest litter may be quite accurately determined in absolute values per unit area from data on the accumulation of dry plant residue and the chemical composition of ash in the A_0' + A_0'' horizons of forest litter (Table 3). By making appropriate conversions, we obtained the data given in Table 4.

Table 4 shows that the total accumulation

Iron podzol

Comparison between semi-decomposed litter-fall and the lower layer of the forest litter

Mn	P	Ca	Mg	S	Fe	Al	Si
3,1	1,6	1,4	1,4	1,2	1,0	0,7	0,5

Humic podzol

Comparison between fresh and semi-decomposed litter

Mn	Mg	P	S	Ca	Si	Al	Fe
1,6	1,5	1,3	1,1	1,0	0,7	0,5	0,2

Comparison between semi-decomposed litter-fall and the lower layer of the forest litter

Ca	Mg	S	Mn	P	Fe	Al	Si
3,3	2,1	2,0	1,2	1,1	0,7	0,6	0,3

Comparison between fresh litter-fall and the lower layer of the forest litter

Ca	Mg	Mn	S	P	Al	Si	Fe
3,6	3,3	2,9	1,9	1,5	0,3	0,3	0,1

Note: Comma represents decimal point.

Accumulation of ash elements in plant residue on humic and iron podzol, kg per ha

Sample	Thickness, cm	Content of pure ash, kg/ha	SiO_2	Al_2O_3	Fe_2O_3	MnO	CaO	MgO	P_2O_5	SO_3
Humic podzol										
Fresh litter accumulated for 1 year		14,500	1,363	0,748	0,235	0,623	5,675	1,827	1,488	1,016
Semi-decomposed litter A_0'	0,5	83,200	10,575	7,754	6,806	2,172	31,283	6,731	6,631	4,950
Forest litter A_0''	4,5	1544,110	577,184	243,659	182,667	33,970	176,490	54,507	106,232	55,742
$A_0' + A_0''$	5,0	1627,300	587,759	251,413	189,473	36,142	207,773	61,238	112,863	60,692
Iron podzol										
Semi-decomposed litter A_0'	0,3	25,300	4,382	3,213	2,080	0,706	7,213	1,318	2,629	1,136
Forest litter A_0''	1,2	669,600	202,122	115,690	55,970	5,958	135,373	25,575	44,049	27,090
$A_0' + A_0''$	2,5	694,800	206,504	118,903	58,050	6,664	142,586	26,893	45,678	28,226

Note: Comma represents decimal point.

of ash elements in the forest litter on humic podzol is 2 to 3 times higher than on iron podzol. The accumulation of silicic acid, aluminum, magnesium and phosphorus in this litter is also proportionally higher than over iron podzol. Calcium, iron and, especially, manganese are an exception. The amount of calcium in the forest litter on humic podzol is 1.4 times higher than in that on iron podzol, i. e., it accumulates less intensively than the general mass of ash substances. This indicates that calcium has a tendency to concentrate to a higher degree in the forest litter of iron podzol. The total amount of iron in the litter over humic podzol is 3.2 times higher than in that of iron podzol, and the manganese content is 5.4 times higher. It follows that iron, and especially manganese, accumulate more intensively in the forest litter over humic podzol. The foregoing shows that the ability of lichens to take up much silicic acid and little calcium has no effect, in this case, on the total accumulation of ash elements in the forest litter over iron podzol. In the case of humic podzol the accumulation of manganese in the forest layer is determined to a considerable extent by shrubs, the roots of which reach into the mineral soil horizons.

In spite of the different role played by the vegetative tops in these two types of forests in the exchange of mineral elements between soil and vegetation, the general course of soil formation in both remains same, i. e., podzols form in both cases. This is attributable to similar conditions of decomposition and transformation of plant residue.

The difference consists in the intensity of these processes. In the white-moss pine forest iron podzols form, which are characterized by low accumulation of organic substances and ash elements in the soil profile. In the green-moss pine forest humic podzols form; in the profiles two to three times more humus and ash elements accumulate than in iron podzols.

Conclusions

1. The mixed surface vegetation (shrub and moss-lichen) in the white-moss pine forest is distinguished by a high content of silicic acid, phosphorus and sulfur and a low content of calcium potassium in its ash. Vegetation in the green-moss pine forest is rich in manganese, calcium, aluminum, phosphorus and sulfur, and poor in silica.

The ash of oat and timothy contains much silicic acid, phosphorus, sulfur and calcium, whereby the calcium content is higher in the roots than in the tops. The clover tops have a very high calcium content and a low silicic acid content, while their roots contain much sulfur and magnesium.

2. The biological uptake series for the mineral A_2 and B horizons of white-moss and green-moss pine forests are very similar. The first place is occupied by manganese, phosphorus and sulfur, and the last, by aluminum, iron and silicon.

The biological uptake series for the forest litter layer show the specific role of the tops of white-moss pine forest vegetation, which intensively accumulates silicon but absorbs little potassium.

3. During the decomposition of plant residue intense leaching of Ca, Mg, S, P, and Mn occurs, whereby the removal of Ca and Mg is the highest. Al, Fe, and Si are only slightly affected by leaching. They accumulate during the decomposition of plant residue.

4. Biological accumulation of ash elements is most pronounced in the forest litter. In the litter of the white-moss pine forest on iron podzol 6.95 cntr/ha of ash elements accumulate, while 2.3 times more ash elements (16.27 cntr/ha) accumulates in the green-moss pine forest on humic podzol.

5. The qualitatively different role of shrubs on humic and iron podzols in the exchange of mineral elements becomes smoothed in the overall process of soil formation. Because of identical conditions of decomposition and transformation of plant residue, the general course of the formation process in both types of forests is the same: in both cases podzols form.

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BIBLIOGRAPHY

1. ALEKSANDROVA, L. N. 1949. Methods of ash analysis during soil investigations. In the collection: Problems of Soviet soil science. No. 12.

2. ASSING, I. A. 1949. The initial phases of wind erosion and soil formation on massive crystalline rocks. In the collection: Problems of soviet soil science, No. 12.

3. BAZILEVICH, N. I. 1955. Characteristics of the cycle of elements and nitrogen in certain soil-vegetation zones of the USSR. Pochvovedeniye, No. 5.

4. BOBRITSKAYA, M. A. 1950. Uptake of mineral elements from massive crystalline rocks by lithophilic vegetation. Trudy Pochvennogo instituta Akad. Nauk SSSR. Vol. 34.

5. BOBRITSKAYA, M. A. 1955. A study of the ash composition of herbs (clover and timothy) in relation to soil-formation in the sod-podzolic zone. Pochvovedeniye, No. 1.

6. DZENS-LITOVSKAYA, N. N. 1946. Ash composition of vegetation in the Saval'-forest-steppe. Pochvovedeniye, No. 4.

7. KACHINSKIY, N. A. 1925. Plant root system in podzolic soils. Trudy Moskovskoy opytnoy stantsii. No. 7.

8. KOVDA, V. A. 1956. Mineral composition of plants and soil formation. Pochvovedeniye, No. 1.

9. KRAVKOV, S. P. 1908. The breaking-up processes of soluble mineral products from decomposing plant debris. Zhurnal: Opytnaya agrenomiya Vol. 9.

10. KURSANOV, A. L. and N. N. D'YACHKOV. 1945. Lichens and their practical utilization. Moscow-Leningrad.

11. LEVINA, V. I. 1960. The mass of annual surface litter-fall in two types of pine forest in the Kola Peninsula. Botanicheskiy zhurnal. No. 3.

12. MINA, V. N. 1955. The nitrogen and ash elements cycle in deciduous forest-steppe. Pochvovedeniye, No. 6.

13. POLYNOV, B. B. 1945. First phases of soil formation on massive crystalline rock Pochvovedeniye, No. 7.

14. POLYNOV, B. B. 1948. Leading ideas in th modern teaching on soil formation and development. In the book: General meeting of the Academy of Sciences of the USSR, dedicated to the 25th Anniversary of the Great October Socialist Revolution Moscow-Leningrad.

15. PONOMAREVA, V. V. and A. M. MYASNIKOVA. 1954. Material for the study of the humic composition and certain problems of the genesis of sod-carbonate soils. Uchenyye zaniski Leningradskogo Cosudarstvennogo Universiteta. No. 36. Pochvovedeniye, Leningrad.

16. REMEZOV, N. P., K. M. SMIRNOVA and Z. I. BYKOVA. 1949. Certain results of a study of the role of vegetation in soil formation. Vestnik moskovskogo universiteta. No. 6.

17. ROZHNOVA, T. A., and L. S. SCHASTNAYA. 1959. A study of the interrelation between vegetation and soils underconditions in the isthmus of Karelia. Pochvovedeniye, No. 1.

18. SMIRNOVA, K. M. 1951. Nitrogen and ash element cycle in a green-moss fir forest. Vestnik moskovskogo universiteta. No. 3.

19. STEPANOV, N. A. 1940. The process of mineralization of leaves and needles falling from trees and shrubs. Pochvovedeniye, No. 9.

20. TROITSKIY, A. I. 1949. Exchange of miner al elements between soil and vegetation. In the collection: Problems of Soviet Soil Science No. 12.

21. YARILOVA, YE. A. 1947. The role of lithophilic lichens in wind erosion. Pochvovedeniye, No. 9.

22. EBERMAYER, E. 1876. Die gesammte Lehre der waldstreu. Berlin.

23. STOKLASA, S. 1922. Über die verbreitung des Aluminims in der Natur.

ICROMORPHOLOGICAL STUDY OF LEACHING AND ODZOLIZATION OF SOILS IN A FOREST

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Many investigators have described the follow- g genetic series of soils: ordinary chernozem leached chernozem — grey forest soil (brown rths — parabrown earths,[1] and sol lessivé in estern Europe) — sod-podzolic soils — pod- lic soil. Already V. V. Dokuchayev (6), who rst used them in the scientific literature by the pular names "chernozem" and "podzol," began e study of the extreme members of this series.

The hypothesis of podzolization was most clear- formulated by K. D. Glinka (3). According to m , this process is initiated by humic (fulvic) ids which decompose the primary minerals, e products of decomposition are removed to e lower horizons, leaving SiO_2 in the upper hori- ns. This results in a relative accumulation of O_2. Vil'yams (1) also shared this opinion on dzolization. However, later, while studying ached (degraded) chernozem and grey forest ils, Glinka (4) came to the conclusion that dzolization is related to the decomposition of imary minerals by water and the removal under e protection of humic soils of mineral colloids, om which Ca is leached, into the lower horizons. cidic decomposition represents only a weak ac- mpanying process. Thus, leaching is the first ase of podzolization, as was pointed out by ssovich and Gedroyts and Zavalishin. The tter suggested that the degree of the podzoliza- n be expressed by curves showing the re- oval of adsorbed Ca (7).

Since the intensity of leaching depends on e water-permeability of soil, it could be ex- cted *a priori* that there must be a difference the movement of colloidal solutions depend- g on soil texture. Glinka pointed out that in ndy soils leaching proceeds evenly, along e profile and well-defined iron layers (ort- and) form in the B horizon. In clay loam ils leaching occurs primarily through pores ere Fe hydrosols and ortstein deposits form.

Summarizing the results of his own investi- tions and the published data, A. A. Rode (12) me to the conclusion that the podzolization ocess undergoes the following consecutive ases of development: decomposition of the imary minerals, the r emoval of colloids, splacement of adsorbed cations, the de- mposition of the secondary minerals, and e removal of newly-formed products. He lieves that the removal of colloids by downward flow is limited, because they must be held back in the upper 10 cm of soil. The order of the phases changes depending on soil texture. In coarse-textured soils Rode distinguishes the following sequence of the phases of podzolization: 1) Appearance of organic matter; 2) Removal of secondary minerals; 3) Physical and chemical weathering of primary minerals and synthesis of secondary minerals; and 4) Decomposition of secondary minerals and transport of decomposition products.

In fine-textured soils podzolization occurs in the following way: 1) Decomposition of primary minerals and formation of secondary minerals; 2) Appearance of organic matter in the soil profile (and acids in the solution); 3) Displacement of exchangeable cations by hydrogen; and 4) Decomposition of secondary minerals. Usually these phases overlap each other. The last phase is characteristic for podzols. Thus, except for the assumption on the impossibility of the leaching of colloids, Rode and Glinka do not differ in their opinions. Yarkov (18) proved that organic-mineral colloids, the degree of dispersion of which is, in his opinion, close to that of true solutions, move in sod-podzolic soils. Therefore, the removal of colloids may occur even when they have not been decomposed. However, special conditions in the B Horizon may cause the formation of secondary minerals different from the original forms. Polynov (11) found that in the B-horizon of podzolic sandy loam mineral xylothile are formed as incrusted films. Recently Yarilova and Parfenova (17) studied clay minerals of the clay fractions from various soils and came to the conclusion that they are very much alike, represent a separate group of highly-dispersed minerals with a three-layer crystal lattice in which silicon has been partially replaced by aluminum.

That clay particles can move without being decomposed is evident from the fact that optically oriented clay layers are found in the pores of various soils (10, 20). Such layers are characteristic for parabrown earths (sol lessivé). These soils have been described in Duchavfour's articles (21). These soils are distinguished by a uniform mineralogical and chemical composition of colloids throughout the profile. On the basis of his detailed study of brown earths in the Ardennes, the Vosges and Gascony (France), Duchaufour came

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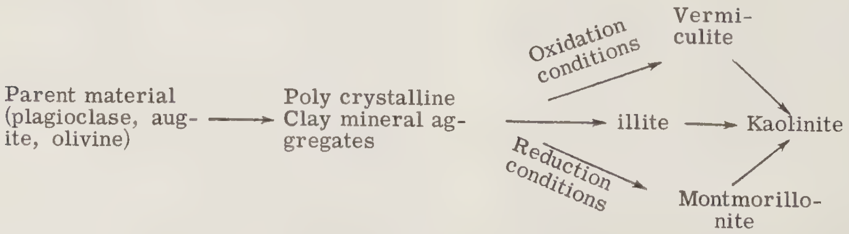
ara braunerde (German) = (para brown earth).

to the conclusion that sol lessivé — podzolized soil represent a genetic series. A removal of clay particles into the B horizon occurs in sol lessivé, and leads to the reduction of the water-permeability of this horizon. The decomposition of colloids and the formation of another B horizon (B_1) above the original one take place in the second phase. When the pH drops below 5 a destruction of structural units and the accumulation of silica powder in the A horizon occur in sol lessivé. Thus, according to Duchaufour, migration during the lessivé (leaching) phase involves mainly clay particles and free Fe-oxides. The phase of actual podzolization begins with the accumulation of acid humus in the upper horizon, the decomposition of secondary minerals, the removal of Al and Fe and the deposition of kaolinite along with Fe_2O_3 in the B horizon. Duchaufour's ideas corroborate those of Glinka and Rode. Differences of opinion consist primarily in that Rode places the main emphasis on the processes of decomposition of secondary minerals and the movement of the resultant products and minimizes the movement of "unchangeable" colloids. Glinka, in contrast to Duchaufour, rightly observes that colloids are hydrated, while being removed into the lower horizons.

Eval'd (16) believes that sol lessivé differs from podzolic soils in that "... separate grains of sand and silt have an iron coating and the B horizon is fairly uniformly developed, so that no illuviation maximum is noticeable." He considers parabrown earth to belong to the podzolic soil group.

Variations in the mineral composition of colloids along the profile of podzolic soil are determined by oxidation-reduction conditions in individual horizons, as well as by the age of the soil and the mineralogical composition of the parent material. Yarkov (18) relates the characteristic distribution of iron minerals in the sod-podzolic soils to the seasonal changes of the rH in their profile.

McAleese and Mitchell (22) suggest the following scheme of the transformation of minerals in soil:


Parent material (plagioclase, augite, olivine)
Poly crystalline Clay mineral aggregates
Oxidation conditions
Vermiculite
illite
Kaolinite
Reduction conditions
Montmorillonite

It is possible that these intermediate clay products are represented by the polycrystalline clay minerals discovered by Rode and Feofarova (13) during the mineralogical analysis of powder in forest-steppe soils. The formation of the profile of podzolic soils is inseparably linked with the varying oxidation-reduction conditions in individual horizons. Therefore secondary minerals, brought from the upper soil layer into the illuvial horizon, can undergo changes.

Thus differences in the mineralogical composition of individual horizons do not exclude the possibility of the movement of secondary minerals in an unchanged state.

It follows that, when the rH is high, primary minerals are decomposed and secondary minerals removed (as colloids) into the lower horizons. Fridland (15) called the latter process "illimerization." We think that the term "leaching" is more fully descriptive of the process because it emphasizes the interrelation between the leaching of colloids from adsorbed Ca + Mg and their removal into the lower horizons. The new term (illimerization) does not reflect the difference between the transport of colloids in podzolic soils and, for instance, in solonetzes or takyrs.

The object of our work was the study of the movement of clay particles in the soil. For this purpose we used micromorphological and electron-microscopic methods of soil investigation. (Table 1).

The description of natural conditions in the Serebryannyy Forest, Podushkino (Moscow Region, Kuznetsev district), Derkula, Volkovo is given in the articles by Zonn (8, 9), Skrynnikova (14), and Gavrilova (2).

The sod-moderately-podzolic medium clay loam (Profile 4) rests on an aluminum-silicate moraine of the Moscow phase of the Wuerm Glaciation rich in boulders. The texture changes with depth to that of fine clay loam. The increase in fineness is primarily due to the increase in the content of clay (10%-30%). At the same time, the content of coarse and medium sand particles also increases with depth (7%-10%-20%-30%) according to data obtained by Skrynnikova (14). We are inclined to think that such distribution of particles means that the upper layer possibly represents a moraine washed in situ. Otherwise, the simultaneous impoverishment in sandy and clay fractions would be difficult to explain.

The mineralogical analysis of the soils showed that the chief soil-forming minerals are quartz and feldspars (microcline, albite, oligoclase). The accessory minerals, amounting to about 5% of the total weight of the soil throughout the profile, are tourmaline, zirconium, amphiboles (in particular, hornblende enriched with titanium), pyroxenes, zoisite,

Table 1

Characteristics of investigated soils

Profile No.	Location	Forest type	Soil	Underlying material
4	Podushkino	Oak forest	Sod-moderately podzolic medium clay loam	Aluminum-silicate-moraine
6	Serebryanyy Forest, Moscow region	Basswood + oak + pine	Slightly sod moderately podzolized sandy loam	
9	Volkovo, Yaroslavl' Region, Rybinsk District	Blackberry-overgrown spruce forest	Slightly sod moderately podzolized clay loam	Aluminum-silicate moraine
15	,,	Green-moss spruce forest	Peat-podzolic-gley sandy loam	Ancient alluvium
2	Derkul', Lngansk Region, Belovodsk District	Oak plantation	Weakly leached chernozem	Loess-like clay loam

inozoisite, garnets, and sillimanite. The A_1 d B horizons show a certain increase in ese minerals as compared to the A_2 horizon. he A_1 horizon contains zirconium which is ost resistant to weathering. Authigenous inerals are represented in the A_1 horizon opal, chalcedony and whewellite.

Table 2 shows the data of the total chemical alysis of soil for Profile 4. A certain relave increase of Al_2O_3 is found in the clay fracon of the B horizon. At the same time the e_2O_3 content is found to increase sharply the wer horizons, which is probably related to e decomposition of mica, amphiboles and roxenes and the removal of colloids into the horizon. Thereby a considerable amount SiO_2 is also removed, and the content ineases in the clay fraction in the B horizon 19% of the total. Consequently, colloidal on compounds are being removed, a fact ich was also observed by Duchaufour in the l lessivé. The total colloidal composition lows the assumption that this soil contains inerals of the illite groups which was born t by our electronmicroscopic investigations ig. 1A).

The micromorphological analysis of polished il sections with an undisturbed structure rofile 4) showed that the A_1 horizon consists subangular grains of quartz 0.01-0.14 mm diameter, surrounded by a mass of organic bstances. Organic-mineral colloids coat th a dense film, the surface of mineral grains. ownish-red plant debris with crystals of ewellite in the cells are found in this horin. Some of the semi-decomposed debris so contains deposits of optically-oriented neral matter (Fig. 1B).

The A_2 horizon contains, in addition to ny quartz grains covered by a humic colloil film, ortsteins ranging from 0.14 mm to mm in diameter. They form mostly around large (0.05-0.09 mm in diameter) quartz grains or their clusters. Sometimes the remains of decomposed hornblende grains are found in the middle of ortstein. The boundaries of the ortstein are clearly defined and bear no evidence of the leaching of Fe_2o_3 in their vicinity. (Fig. 1C). Mineral grains (quartz) have a certain orientation and a poorly expressed micro-stratification. Accumulations of organic matter occur at places. Feldspars are rare.

The B horizon consists mainly of small crystals with a few large grains of quartz (0.2-0.7 mm in diameter). Some brownish spots of optically-oriented clay are also found (Fig. 1D). There are ortstein grains of the same type as those found in the A_2 horizon, but their surfaces are slightly eroded as a result of the movement of Fe colloids. Grains of quartz and chalcedony are coated with a film. Pores and cracks are filled with oriented clay substances. The B_2 C horizon presents a similar picture. It contains large amounts of optically oriented clay forming spots throughout the entire horizon.

These data on the mineralogical composition of the soil and its micromorphology are indicative of: 1) the syngenetic origin of the upper medium clay loam and the underlying moraine; 2) the leaching of colloids into the lower soil horizons and the accumulation of Fe in the lower horizons. The latter phenomenon points to the intense weathering of primary minerals (mica, amphiboles, pyroxenes) and the movement of the products of their decomposition in the upper horizons; 3) the prevalence of illite among secondary mineral, which moved into the lower horizons along with Fe compounds. The accumulation of Fe compounds in the lower horizons results primarily from the increase of the clay contents.

The slightly sod moderately-podzolic sandy

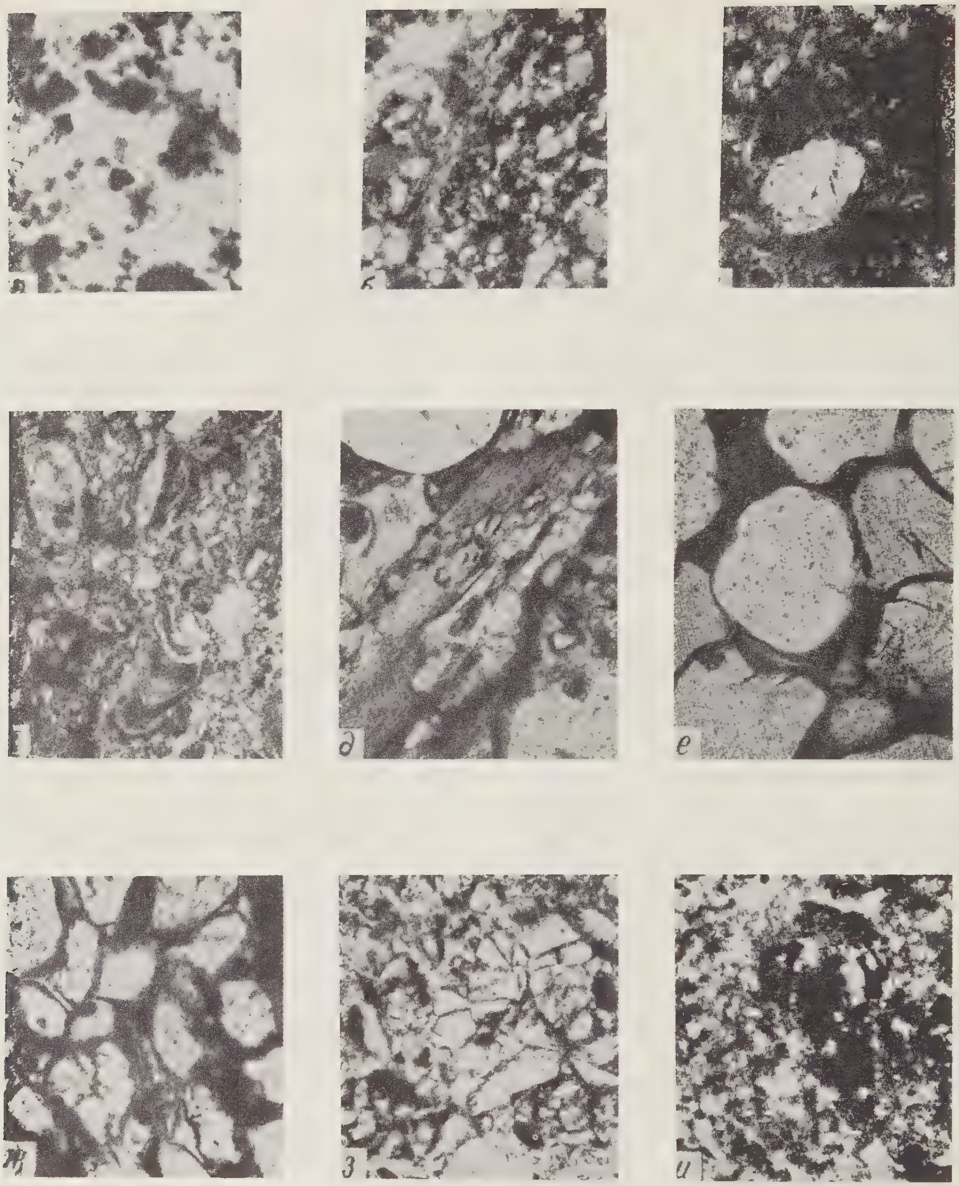


Fig. 1. - Characteristics of leaching and podzolization processes in soils in a forest.

a - d - Profile 4 a - B horizon. An electronmicroscope picture of colloids, X 15,000; b - i - enlarged 100 times. b - A_1 horizon, with an analyzer. Optically oriented colloids in plant debris tissues. c - A_2 horizon, without an analyzer. Fe oxides (ortstein) near a large grain of quartz; d - B_1 horizon, without an analyzer. Colloidal films in pores and around mineral grains; e - f - Profile 6; e - A_2 horizon, without an analyzer. A decomposing grain of hornblende; f - B_1 horizon, without an analyzer. Films around mineral grains and "cuff-like" Fe colloidal accumulations between grains; g and h - Profile 15; g - B_1 horizon, without an analyzer. Films of Fe colloids near grains of quartz and feldspar. h - gley horizon, without an analyzer. Mineral grains are considerably smaller than in the B_1 horizon; i - Profile 2, B_1 horizon, without an analyzer. An accumulation of humus of the type of ortstein grains.

Table 2

Content of SiO_2, Al_2O_3 and Fe_2O_2 in sod-moderately podzolized soil, Profile 4, Podushkino, Moskow Region

Horizon	Soil					Clay					Clay components, %						Clay content, %	Humus
	in moles										of soil			of the total content of component			%	
	Al_2O_3	SiO_2	Fe_2O_3	$\frac{SiO_2}{Al_2O_3}$	$\frac{SiO_2}{Fe_2O_3}$	Al_2O_3	SiO_2	Fe_2O_3	$\frac{SiO_2}{Al_2O_3}$	$\frac{SiO_2}{Fe_2O_3}$	SiO_2	Al_2O_3	Fe_2O_3	SiO_2	Al_2O_3	Fe_2O_3		
A_1	0,097	1,29	0,013	16,0	100	0,18	0,84	0,04	4,7	21	6,5	2,31	0,83	8,0	23,4	40,0	13,2	3,09
A_2	0,097	1,36	0,015	17,0	90	0,22	0,84	0,06	4,0	14	6,0	2,69	1,18	7,5	27,5	55,1	12,0	0,62
B_1	0,140	1,23	0,020	8,8	61	0,25	0,87	0,07	3,5	12	14,0	6,75	2,85	19,0	47,2	83,8	27,0	0,43
B_2	0,130	1,17	0,035	9,0	33	0,21	0,93	0,08	4,4	11	17,9	7,02	3,81	25,2	50,0	65,7	32,0	—

Note: Comma represents decimal point.

loam (Profile 6) rests on old alluvium under climatic conditions similar to those of the preceding soil. The texture of this soil indicates that clay particles move from the upper into the lower horizons.

The amount of accessory minerals is 0.3%-0.1% and less. Pyroxene (including hypersthene), amphiboles, cyanite and garnet predominate among them.

Results of the total chemical analysis of the soil in the Serebryanyy Forest (Table 3) show an increase in the content of Fe in the lower horizons.

A deviation from this tendency in the upper part of the B_2 horizon is related to the presence of a layer of a coarser texture.

Our micromorphological investigations of this soil produced a slightly different picture than for the medium clay loam. The A_1 horizon consists here of subangular quartz grains, 0.5-0.9 mm and bigger in diameter. There are also small grains of feldspars, accumulations of chalcedony and rock fragments. Reddish iron-humic films, one thousandth of a millimeter thick, are found around larger grains and oriented flakes of a clay substance. In the A_2 horizon there are more films and spots, the number of grains of feldspars (albite and microcline) and amphiboles increases and these grains become bigger in size (Fig. 1E). The number and the size of the grains of feldspars increase even more in the B horizon. Here Fe colloids form thin films around quartz grains and accumulate in the inter-spaces between mineral grains (Fig. 1F).

Thus, coarse-textured soils have a more uniform distribution of colloids in the form of films around individual grains of quartz and feldspars. The quantitative distribution of feldspars indicates that they are undergoing decomposition in the upper horizons. The A_2 horizon of this soil contains some splitting grains of accessory minerals which are resistant to weathering.

A comparison of the two podzolic soils from areas with very similar climatic conditions (total annual precipitation 550 mm and total annual evaporation 545 mm) shows that in coarser-textured soils colloids move uniformly throughout the profile, which leads to the formation of ortsand.

Our micromorphological investigations of a peat-podzolic-gley soil on an old river alluvium (Profile 15) showed substantial differences in the properties of soil in the various parts of the profile. In the A_2 horizon, just as in the case of Profile 6, quartz grains up to 0.07-0.7 mm in diameter predominate. It also has rock fragments and brown iron grains (ortstein?).

In the B_1 horizon, the amount of feldspars increases from 1%-2% to 6%. Iron concretions and brown films are found near the grains of quartz and feldspars (Fig. 1G). The size of minerals is somewhat smaller than in the A_2 horizon. There are some preserved grains of amphiboles which are not presented in the A_2 horizon. The B_2 horizon has more feldspars and amphiboles but considerably fewer organic-

Table 3

Content and ratio of Al_2O_3, Fe_2O_3 and SiO_2 (in moles) in slightly sod moderately podzolized soil, Serebryanyy Forest

Horizon	SiO_2	Al_2O_3	Fe_2O_3	$\frac{SiO_2}{Al_2O_3}$	$\frac{SiO_2}{Fe_2O_3}$	Clay fraction, %
A_1	1,50	0,054	0,011	27,7	145	4,5
B_1	1,44	0,064	0.021	25,5	69	4,8
B_2	1.54	0,031	0,014	49,7	110	1.6
B_2	1,44	0,058	0,030	24.8	45	7,7

Note: Comma represents decimal point.

mineral films than the B_1 horizon.

Under reduced conditions, the main soil mass of the gley horizon consists primarily of the same mineral grains, measuring <0.2 mm in diameter, that are found in the A and B horizons. It contains many amphiboles (Fig. 1H) and some oriented scales of clay.

The distribution of minerals in sandy loam podzolic soils is the same as in Profile 6. However, there are certain differences in the form of colloidal films. Thus, while in the B horizon they are not oriented, in the gley horizon they occur as flakes of oriented clay. This indicates a difference in the formation of clay minerals, which is apparently related to the oxidation-reduction conditions in various soil horizons.

The medium clay loam, slightly-peaty strongly podzolized soil (Profile 9) on the aluminum-silicate moraine of the Kalinin phase of the Wnerm Glaciation is located not far from Profile 15 in a blackberry-spruce forest. In its mineral composition, it is similar to the sod-moderately podzolic soil of the Podushkino Forestry. The heavy mineral fraction accounts for 0.1%-0.2% and is slightly smaller than in Profile 4. The accessory minerals are represented predominantly by garnets, pyroxenes, epidotes, amphiboles, enstatite, sillimanite and by individual grains of tourmaline. The fact that this soil contains a lesser amount of accessory minerals is probably indicative of their more intensive weathering and decomposition, which is undoubtedly related here with very pronounced podzolization.

Our study of the sod-podzolic and podzolic soils of the Moscow and Yaroslval' Regions showed that during podzolization, the most intensive decomposition of primary minerals (feldspars and accessory minerals) occurs in the upper horizons. Fe and Si are removed (in the clay fraction) into the lower horizons. Oriented and non-oriented colloids are deposited in the B horizon. Colloids move differently in sandy and clay loam soils. In the first the solutions move near mineral grains, forming thin films around them. In the latter case colloids line the pores, forming various accumulations of sols, changed into gels and cryptocrystalline formations.

That the primary minerals are being decomposed in the sod-podzolic (and in podzolic) soil is evidenced by brown formations around the grains of mica, pyroxene and amphiboles, as well as by the fact that mica (especially biotite) is almost completely decomposed and the content of feldspars increases with depth. In certain cases the A_1 horizon content of accessory minerals increases slightly as compared to the A_2 horizon. This can be explained by the protective role played by humic acids which are more saturated with cations. This saturation is partially caused by Ca in the litter. Thus, in the Podushkino Forestry up to 90 kg/ha of CaO is annually returned to the soil through the litter (unpublished data compiled by Ye. A. Kuz'mina). The amount of Ca adsorbed in the upper layer amounts to 1.3-5.0 tons/ha in terms of CaO. Consequently, a considerable part of adsorbed Ca may be of biological origin. The results of the total chemical analysis of colloids and soil show that more than 90% of the Ca adsorbed by the soil is contained in the clay fraction, which determines the amount of exchangeable Ca in the soil, while in the coarser fractions Ca is part of the minerals.

Thus, in the upper horizon of the sod-podzolic soil the colloids are more saturated with Ca and to a certain degree protect the minerals from decomposition. According to our micromorphological analysis, all mineral grains are covered with more or less defined colloidal films. However, even though all colloids are similar to their chemical composition, they differ in the degree of hydration in various horizons of the sod-podzolic soil (content of adsorbed and constitutional water). If the total chemical analysis of the soil shows increased ignition losses with depth (Table 4), the re-calculated data indicate that this occurs as a result of the increase in clay content. At the same time the hydration of colloids decreases with depth.

The hydration of colloids is pronounced in the A_2 horizon which promotes their mobility. Under the protection of hydrophilic humic sols, which are easily hydrated, other colloidal compounds become readily movable. The accumulation of colloids (in particular, Fe) in the lower horizons testifies to their slight dehydration in these horizons.

Table 4

Ignition loss in sod-podzolic soil and its clay fraction, and their ratio in %; Profile 4

Horizons	Ignition loss			
	of soil	of clay	in clay, of soil weight	in clay, of total loss
A_1	6,60	19,80	1,9	29
A_2	2,81	12,40	0,8	28
B_1	4,36	7,45	1,5	35
B_1C	5,04	8,00	2,4	48

Note: Comma represents decimal point.

Since the total ignition loss increases in the ower horizons, their content in constitutional vater also increases (in percent of soil weight). pparently leaching is inseparably connected vith the hydration of colloids and their disersion by water. The movement of colloid ols is a very common natural phenomenon, as videnced by the data compiled by Minashina 10). Brewer and Haldanc (19) note that cologidal films are more oriented in sands than n clay loam soils. Their orientation occurs vhile they are being carried by both upward nd downward movement of water.

Micromorphological investigations of leached hernozem from the Derkul' Experiment Staion testify to the movement of colloids during eaching. Derkul' chernozem rests on loess nd does not contain much accessory minerals (<0.1%), among which pyroxenes, disthene, garnet and tourmaline predominate (Table 5).

Incrustations of chalcedony and grains of quartz measuring ~0.3 mm in diameter are found in the A horizon. Other minerals are difficult to detect because a large amount of humic colloids fills small pores and surrounds the mineral grains with a thick film. In the plant residues one can easily see crystals of carbonate and whewellite. The latter are usually of a reddish color. In the deeper portion of the profile a part of the carbonates is deposited in the needle-shaped crystals. In the lower part of the A and B horizons the diameter of quartz grains increases to 0.12-0.2 mm and the amount of such accessory minerals as garnets, pyroxenes, etc., increases. There are also scaly films of weakly oriented colloids and deposits of the ortstein type (Fig. 1I). Part of the colloids occupies the pores; these colloids are not optically oriented but occur in the form of incrustations. Thus, the peptization of colloids occurs in chernozem under the influence of downward flow of water originating in the upper soil horizons under the effect of forest stands. The C_k horizon contains a large amount of Ca carbonate, distributed by diffusion. In the lower part of the horizon the quartz grains decrease to 0.1-0.06 mm in diameter.

Conclusions

1. Colloids forming during the process of podzolization are carried downward by water into the lower horizon. They include Fe and SiO_2 colloids in the form of hydrosols under the protection of humus sols.

Table 5

Mineralogical composition of soils

Soil	Light fraction, spec. gravity <2.85	Heavy fraction, spec. gravity <2.85	Clay	Authigenous
Sod moderately podzolized, Profile 4	Quartz, microcline, albite, oligoclase, mica	Tourmaline, zirconium, hornblende (enriched with Ti), pyroxene, zoisite, clinozosite, sillimanite, garnet, mica	Illite, montmorillonite, Fe compounds	Opal, chalcedony, whewellite
Slightly sod-moderately podzolized, Profile 6	Quartz, microcline, albite	Pyroxene (including: hypersthene, amphiboles, kyanite, garnet)	Fe compounds and illite	Chalcedony
Peat-podzolic-gley, Profile 15	Quartz, microcline, plagioclase	Amphiboles, garnet, disthene, epidote	Illite, Fe compounds	Chalcedony, calcite
Weakly leached chernozem, Profile 2	Quartz, orthoclase, microcline	Tourmaline, garnet, disthene, pyroxene	Montmorillonite	Carbonate, chalcedony, opal

2. The nature of the movement and deposition of colloids depends on soil texture. In sandy soil colloids precipitate in the form of films around minerals and in the form of accumulations in the spaces between the grains. In clay loam soils colloids move mostly through pores, so that oriented colloids form scaly films, concentric stratifications in pores, and diffuse streaks and spots.

3. The removal of colloids into the illuvial horizon changes the oxidation-reduction conditions in the profile of soils toward reduction, especially in the illuvial horizon, which leads to their dehydration and a change in their mineral composition. The role of the rH is substantiated by our investigations on a peat-podzolic soil (Profile 15) which showed a sharp distinction between the micromorphology and mineral composition of the gley and other horizons.

4. The orientation of mineral colloids is observed in plant tissue.

5. All this leads to the conclusion that the previously described soils colloids are moved by water flow. Podzolization is accompanied by the intensification of the weathering of primary minerals, while leaching, or lessivage, is the initial phase of podzolization and the accompanying process during the later phases of podzolization, which was first noted by Glinka and confirmed by Duchaufour. There may be no substantial differences in the composition of secondary minerals, as long as the oxidation-reduction conditions in the soil profile are of the same type. However, during the development of the process of leaching of colloids new minerals are formed in the illuvial horizon.

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BIBLIOGRAPHY

1. VIL'YAMS, V. R. 1939. Soil science.

2. GAVRILOV, K. A. 1959. Report for 1958. Manuscript at the Forest Institute, Academy of Sciences of the USSR.

3. GLINKA, K. D. 1911. Problem of the difference between the podzolic and bog groups of weathering. Yur'yev. (TARtu).

4. GLINKA, K. D. 1931. Soil Science.

5. GINZBURG, I. I. and A. A. RUKAVISHNIKOVA. 1951. Minerals of the weathering crust in the Urals.

6. DOKUCHAYEV, V. V. 1949. Cartography of Russian soils. Selected works. Vol. 3. Sel'kozgiz.

7. ZAVALISHIN, A. A. 1936. The relationship between the processes of removal and accumulation in podzolized forest-steppe soils. Problemy sovremennogo pochvovedeniya. No. 1.

8. ZONN, S. V. and A. P. SHIMANYUK. 1949. The problem of the effect of soil conditions on the development of root of wind-blown pine in the Moscow region. Byulleten' Moskovskogo Obshchestva Ispytateley Prirody. 54(2).

9. ZONN, S. V. and I. N. VASIL'YEVA. 1954. Effects of plantations on changes in the physical properties of the Derkul' steppe chernozem. Trudy Instituta lesa Akad. Nauk SSSR Vol. 15.

10. MINASHINA, N. G. 1958. Optically oriented clays in soils. In: Pochvovedeniye, No. 4.

11. POLYNOV, B. B. 1956. Secondary minerals in ortstein horizons, 1915. Quoted from: "Selected Works." Akad. Nauk SSSR.

12. RODE, A. A. 1937. The podzol-forming process. Akad. Nauk SSSR.

13. RODE, A. A. and I. I. FEOFAROVA. 1955. Some data on the mineralogical composition of "silica powder" in forest-steppe soils. Pochvovedeniye, No. 9.

14. SKRYNNIKOVA, I. N. 1958. The soils of the Podushkin Forestry. Akad. Nauk SSSR.

15. FRIDLAND, V. M. 1958. Podzolization and illimerization. Pochvovedeniye, No. 1.

16. EVAL'D, E. O. 1956. Certain main forest soil types and their nomenclature in Germany. Pochvovedeniye, No. 9.

17. YARILOVA, YE. A. and YE. I. PARFENOVA. 1959. Some data pertaining to the description of clay minerals in colloidal soil fractions. Pochvovedeniye, No. 2.

18. YARKOV, S. P. 1956. Seasonal dynamics of certain soil processes. In: Report to the 6th International Congress of Soil Science. Akad. Nauk SSSR.

19. BREWER, R. and A. D. HALDANE. 1957. Preliminary experiments in the development of clay orientation in soil. Soil Sci., Vol. 84, 4.

20. DALRYMPLE, J. B. 1958. The application of soil micromorphology to fossil soil and other deposits from archaeological sits. J. Soil Sci., vol. 9, 2. Oxford.

21. DUCHAUFOIR, PH. 1951. Lessivage et podsolisation. Rev. forest. franc., 10.

22. McALEESE and MITCHELL. 1958. The basalt soils of Northern Ireland, J. Soil Sci., Vol. 9, No. 1.

HARDNESS DYNAMICS OF CERTAIN SOILS IN THE MIDDLE TRANS-VOLGA AND SOUTH-URALS REGIONS

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According to Shchukin (22, 23), soil hardness s the property of the soil to resist penetration y solid objects of certain shapes and sizes uch as, spheres, cones, cylinders, etc. Hardness indicates the ability of the soil to withtand the destructive mechanical impact of external forces: the effects of plant roots, tilling mplements, raindrops, etc. Internal forces may also effect an increase or decrease of soil trength (swelling and shrinkage) and, thus, an ncrease or decrease of hardness.

Hardness is a dynamic property which varies reatly depending on changes in the moisture ontent of the soil, its compaction under load, tc. Kachinskiy (10, 11) and certain other cientists call this property the power of resisance of the soil to cleaving, and compare the enetration of an instrument under load into he soil to the cleaving action of plant roots. Other scientists, for instance, Buromskiy (3), nd Zheligovskiy (9), consider "hardness" as he coefficient of volumetric deformation or rumpling of the soil, and express it in kg/cc nstead of kg/sq cm, which denotes hardness. ll this goes to show that various scientists nterpret this property differently.

Sometimes the term "density" (the ratio beween the mass and volume of a body) is inorrectly used in referring to hardness. Hardess is measured with hardness gages, which re also wrongly called "penetratometers," ccording to the old terminology. At present here are a great number of various hardness ages, which are listed in the works of Kahinskiy (12), and Bakhtin (2).

Soil hardness is a complex mechanical roperty, which consists of several simple nechanical strains such as compaction, shearng, friction, etc. Soil hardness is being studied:

1) to determine the special genetic characeristics of various types of soil. Surface, as ell as underlying, genetic horizons of various oils have fairly constant hardness values, all ther conditions being equal;

2) to characterize various soils as media nd habitat of individual plant organs, such as oots, rhizomes, tubers, etc. Very hard and ohesive soils interfere with the development f these plant organs. Even though certain lants develop a great strength throughout different phases of their growth, which cleaves the soil, they may not have enough strength to overcome the extreme hardness of the soil and perish. This happens, for example, as pointed out by Dolgov (7, 8), Gorbunov and Bekarevich (6), and others, to tea plants when their roots reach very hard horizons or when a soil crust forms.

To diminish the hardness of the soil and improve conditions for plant growth, the soil is cultivated and loosened before sowing.

3) To characterize soils from the point of view of their trafficability by agricultural machines, vehicles, animals, etc. In measuring hardness, we evaluate the bearing capacity of the soil, etc.

4) To evaluate soils from the point of view of their cultivation. The harder the soil, the stronger it is, the more mechanical effort is required for tillage. Thus, great importance is given to soil hardness measurements in testing soil cultivating equipment.

5) To determine the deformations experienced by the soil cultivating equipment and tractors in relation to: (a) the determination of the depth and quality of cultivation and changes in the relationship between individual genetic layers and their parts; (b) the measurement of destructive deformations that may be inflicted upon the soil, should it be tilled when it is excessively dry or wet and excessive compaction of individual genetic horizons, resulting from working the soil, or from natural conditions.

6) To estimate the erodibility and other physical soil properties, are closely related to its hardness. Thus, for instance, Keen (15), Kachinskiy (11, 13, 14), Shchukin (23), and later Kikvadze (16, 17), Morozov (19), Bakhtin (2), and others, proved that there is a high correlation coefficient between soil hardness and its specific resistance during plowing, moisture content, structure, etc.

The foregoing shows that hardness measurements are of great technological importance to the working of soil. An extensive study in this field was started at the V. V. Dokuchayev Soil Institute, Academy of Sciences, USSR, by A. S. L'vov in 1940, at the suggestion of N. A. Kachinskiy, which was continued by us starting in 1946. The hardness meters ("penetratometers") of V. P. Goryachkin (23), Kachinskiy (11), Golubev (5), Revyakin (21), and Vysotskiy (4) were used in the study.

The soils studied included: 1) fine clay loam ordinary chernozem, found normally in terraces, chernozem-like meadow-solonetz, solonetz and saline soil of the irrigated Kutuluk District, Kiybyshev Oblast'; 2) meadow-steppe fine and medium clay loam leached chernozem, and meadow chernozem of the Shadrinsk and Kurgansk experimental stations. The studies were conducted from 1940-1956.

Let us examine the data obtained in the irrigated area along the Kutuluk River, where complex studies were conducted by the Academy of Sciences, USSR, part of which comprised studies on the physical and mechanical properties of the soil.

Observations were made on genetic horizons of the foregoing soils, of five different moisture contents.

A short morphological and physical and chemical description of these soils is given below, based on data obtained by Novikov (20) and Kocherina (18).

Profile 2003. Ordinary chernozem from a terrace, slightly eroded (lower field, stubble). This soil is prevalent in the area. The average thickness of the A_1 horizon is 29 cm, varying from 25-36 cm and that of the $A + B_1$ horizon,52 cm. The soil effervesces at a depth of 51 cm. The greatest accumulation of carbonates is found at a depth of 85-105 cm. The texture is that of a fine clay loam with coarse silt and clays (the physical clay content ranges from 54%-76%). These chernozems contain 5.5%-7% of humus. The total amount of exchangeable calcium and magnesium in the A_1 horizon varies from 38-52 meq. The blocky-granular structure and high humus content contribute to the good agronomical properties of these chernozems.

Profile 2014. Terrace Ordinary chernozem, weakly solonetzic, showing evidence of salinization (fallow). The B_1 horizon shows weak signs of salinization, expressed by slight compaction. The structure of the soil is coarse, angularly-blocky, with a slight slickness on the faces of its structural units. Salinization is expressed by the presence at a depth of 60 cm of white salt (Na_2SO_4).

In contrast to Profile 2003, the physical clay content of Profile 2014 decreases to 32%-38% in the layer from 0-45 cm, so that it may be classified as a medium clay loam, according to its texture.

Profile 2007 (or according to Novikov (20), 7-44). Chernozem-like solonetzic meadow soil. The Kutuluka solonetz depression is virgin land (pasture). This type of soil is also common in the area. It belongs to the initial stage of formation of genetic horizons. All together, the genetic horizons of the meadow soils of the Kutuluk region are 15-20 cm thick. Below these horizons the soil-forming processes are weak. These are indications of water-logging at a depth of 50 cm. The soil frequently effervesces at the surface. The humus content varies greatly (between 5% and 11%). The fine clay loam is compacted at the surface.

Profile 2008. Crust-columnar solonetz; virgin land. The A_1 horizon reaches a thickness of 4 cm sod. The soil blocks break into plate-like units with differently colored surfaces (fine clay loam). The columnar B_1 horizon with silica powder reaches a depth of 17 cm. The individual lumps of soil formed on crumbling the columns. The B_2 horizon has a nut-like, lumpy structure, moist, compact and reaches a depth of 45 cm. The BC horizon is found at a depth from 45-95 cm. It has a nut-like, lumpy structure and contains clay. This horizon is underlain by a layer with a texture which gradually becomes coarser with depth. The humus content varies from 4%-3% to a depth of 15 cm, decreasing sharply below (0.85% at a depth of 35-40 cm).

The adsorption capacity in the upper 4 cm of the soil is 14 meq, and that from a depth of 10-24 cm varies from 22-27 meq. The exchangeable sodium content in these layers is, respectively, 9% and 41%-47% of the total adsorption capacity.

Profile 2013. The solonetz-solonchak is takyr-like. A pasture near Kutuluk settlement. Small patches of these soils with a bare yellowish white surface stand out against the vegetation background. The takyr-like solonetz-solonchaks have a thin (1-3 mm) whitish crust on the surface. The B_1 and B_2 sub-horizons are, more or less, distinct, while below them the soil profile is weakly differentiated. Because of the proximity of sub-soil water containing carbonate the HCl of these soils effervesces at the surface. There are large salt accumulations of a dirty-white color at a certain depth. Spots of organic matter are an evidence of oxidizing processes. At the surface the fine clay loam is lumpy, compacted, and breaks down into nutty structural units. At the depth of 10-38 cm it is blocky and fine-grained, and more friable than at the surface. At a depth of 38-56 cm it is first prismatic to blocky, and then lower, compact and blocky to prismatic.

In using Goryachkin's hardness gage, the most representative data were obtained with a cylindrical plunger, having a cross-section of 2 cm², Figure 1A and 1B show curves of the variations in hardness for terrace ordinary chernozem (Profile 2003 and 2014) in individual genetic horizons down to a depth of 50 cm.

Figure 1A shows variations in hardness and moisture content of the soil before and after irrigating the lower stubble field. Before irrigation the hardness of the soil at a depth of 10-12 cm (Curve 3) reached 20-24 kg/cm², probably representing the layer compacted by agricultural machines. Below, to a depth of 20 cm, the hardness decreased. At depths greater than 20 cm, hardness gradually increased to reach 48 kg/cm² at 50 cm.

The first determination of hardness after irrigation gave the lowest value, reaching 15-16 kg/cm² at a depth of 10-12 cm. The second determination gave approximately the mean hardness value for the plowed layer, which was higher in the upper portion of the layer after irrigation than before irrigation (which is considered natural when friable soils become more cohesive on being wetted). After wetting, the influence of the plow pan was not felt.

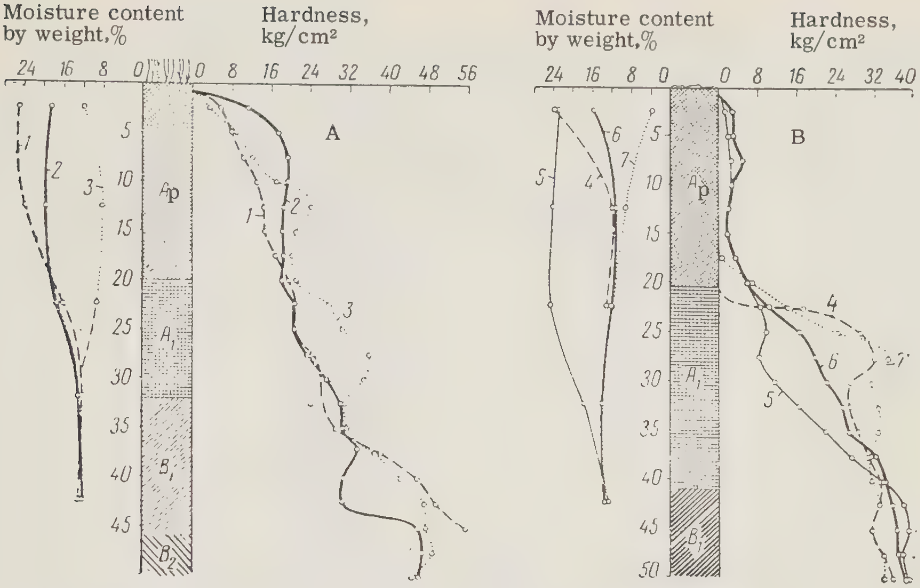

Fig. 1. - Dynamics of soil hardness in genetic horizons as related to moisture content.

A - slightly eroded, terrace ordinary chernozem (Profile 2003), stubble of spring wheat; irrigated on Sept. 6, (55-60 mm of water); B - terrace, slightly solonetzic ordinary chernozem (Profile 2014), black fallow; irrigated Sept. 2 and Sept. 9 (75-80 mm of water).

Curves 1 and 4 hardness and moisture content determined Sept. 10 and Sept. 6; curves 2 and 5, on Sept. 21 and Sept. 17; curve 6 on Sept. 10; curves 3 and 7, measured before irrigation Sept. 10 and Aug. 29.

The hardness of chernozem gradually inreases with depth, in our case to the depth of e B_1 horizon, with certain deviations, which attributable to wide variations in the distribution of moisture and organic matter as well as e actions of plant roots and burrowing aniials.

Figure 1B shows variations in hardness for similar, but weakly solonetzic chernozem of arying moisture contents (Profile 2014, middle eld, fallowed). Hardness was determined efore irrigation (curve 7) and three times fter irrigation (Curves 4, 5 and 6). In the lowed layer of 20 cm hardness was so small efore and after the first irrigation that it ould not be measured by our hardness gages. t the time of second and third determinations, fter the soil had dried up, it increased slight-, varying in the plowed layer from 2-4 kg/cm². elow 20 cm, maximum hardness was also ecorded before irrigation, reaching 36 kg/cm² urve 7), or slightly more than in the preced-g profile, as a result of a certain solonetza-on of the soil.

Greater hardness was also observed during e first determination after irrigation because e water had not yet time to wet the soil below e plowed layer. Once the soil is moist, its rdness decreased to 10-17 kg/cm². All cur-s for depths from 38-40 cm closely agree ecause of the uniform moisture content and ndition of the soil.

All curves in Figure 1 show a clear difference in the effect of agricultural practices (fallow and stubble) on both profiles and also a close dependence of hardness on moisture. A gradual increase in hardness with depth is noted.

Figure 2A shows hardness curves for chernozem-like solonetzic meadow soil (Profile 2007). All together, five hardness determinations were made.

A maximum hardness (of 50-60 kg/cm²) was recorded in the surface layer when dry (curve 5) and a minimum of 14-16 kg/cm² during the first determination after irrigation (curve 1). On drying, hardness increased. By the time of the fourth determination (curve 4), hardness reached its initial value before irrigation. The deviation of third hardness test (curve 3), from the general trend, can, apparently be explained by the diversified nature of the field or by the delayed in the softening of the soil by the time the third reading was taken and rapid drying before the fourth determination.

The dependence of hardness of soil moisture content is clearly defined. A sharp increase was noted in the hardness of the B_1 horizon, which is slightly solonetzic and, morphologically, has a columnar structure of a high compressive strength. A maximum hardness of 56-60 kg/cm² was recorded at a depth of 25 cm. Below 30 cm, i. e., in the B_2 horizon, hardness decreases because the soil is less solonetzic.

As in the preceding case, the hardness of

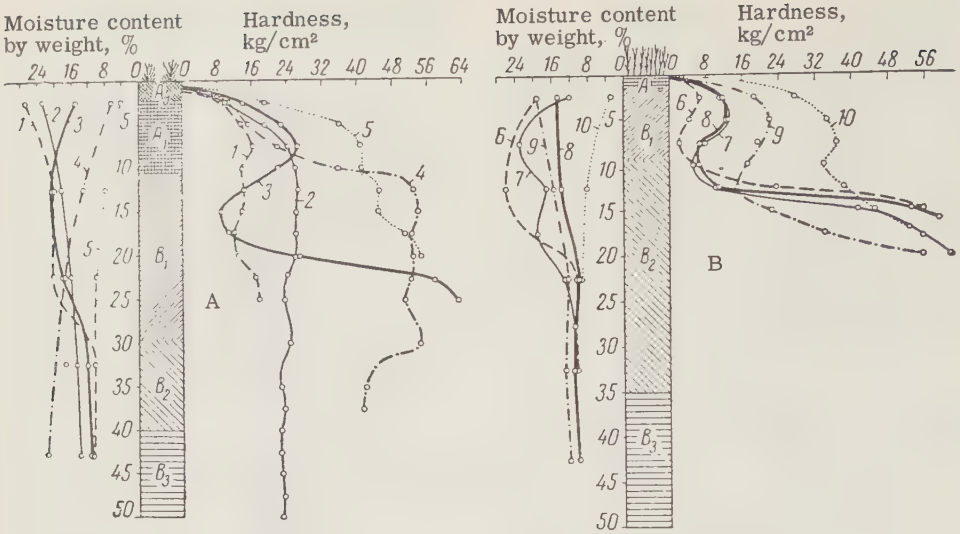

Fig. 2. - Dynamics of soil hardness in genetic horizons as related to soil moisture content.

A - chernozem-like, solonetzic fine clay loam meadow soil (Profile 2007), virgin land; B - crust-columnar fine clay loam solonetz (Profile 2008), virgin land; irrigated Aug. 28 (100-120 mm of water).

Curves 1 and 6 - hardness and moisture content measured after irrigations Aug. 30 and Aug. 31; curves 2 and 7, measured Sept. 5; curves 3 and 8, Sept. 13; curves 4 and 9, Sept. 27 and Sept. 28; curves 5 and 10 - hardness and moisture content of the soil before irrigation on Aug. 28.

crust-columnar solonetz (Profile 2008) was determined four times after irrigation as the soil was drying. Figure 2B shows curves for variation of hardness with depths for each date, as well as moisture variations (left part of the figure).

Crust-columnar solonetz shows considerable hardness starting at a depth of 5 cm, that is at the "columns," which reaches 36 kg/cm² at low moisture content (curve 10). At a depth of 10-12 cm there is a layer, which readily absorbs moisture and therefore has a sharply reduced hardness after wetting. Below 12-13 cm all curves again show a sharp increase in hardness, reaching a maximum of 60 kg/cm² at a depth of 18 cm, whereby the moisture content of the soil decreases because of insufficient wetting at this depth resulting from the lower permeability of the solonetz layer.

The hardness readings clearly show the difference between curst-columnar solonetz and other soils, and also demonstrate the dependence of hardness on the moisture content of the soil.

Figure 3 shows hardness variations in individual genetic layers of takyr-like solonetz-solonchak (Profile 2013) in relation to moisture. Maximum hardness is found for the lowest moisture content before irrigation (curve 5), and the minimum, for the first reading after irrigation (curve 1). Takyr-like solonetz-solonchak is more easily penetrated by the penetratometer plunger than crust-columnar solonetz. From the surface down to a depth of 12-15 cm hardness increases sharply to 45-55 kg/cm² and then remains constant to a depth of 50 cm. The accumulation of free salts between soil blocks apparently promotes their cleavage during the penetration of the rod to a depth of 50 cm, which is not observed in the crusty-columnar solonetz (Fig. 2B).

The Table gives numerical hardness data for the genetic horizons of the five soils studied to a depth of 50 cm. The numerators show hardness in kg/cm², and the denominators, the absolute moisture content in percent.

It may be concluded from Figures 1 to 3 that hardness determinations, under the same conditions, clearly reflect the genetic differences between various soils and their horizons, and also confirm the close relation between the hardness and moisture content of soil. According to our data, obtained in 1946 (2) for terrace ordinary chernozem (Profile 2003), the reciprocal correlation coefficient between hardness and moisture content is very high, reaching 0.93-0.96, when the cylindrical plunger of Goryachkin's hardness gage is used, and 0.99, when Kachinskiy's hardness gage is used. Thus, this correlation is close to a functional dependence. Our hardness determinations allowed us to make certain conclusions on methods and depth of mechanical soil cultivation (Fig. 4, A and B).

Hardness was determined at the Shadrin experimental station (Fig. 4A) with a Revykin-

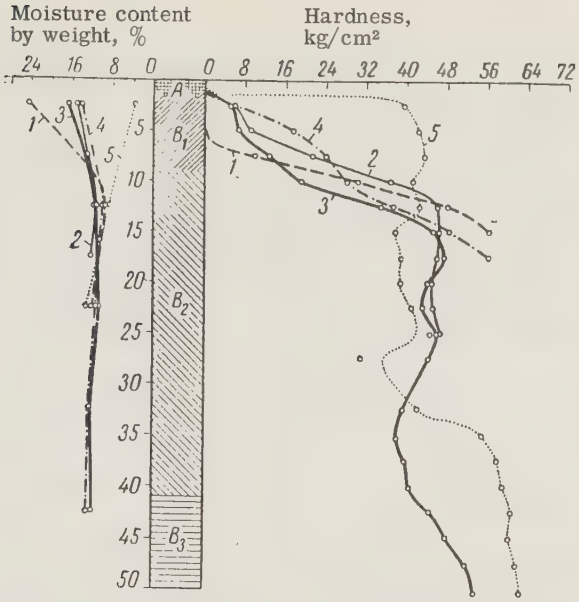

Fig. 3. - Hardness dynamics of takyr-like solonetz-solonchak, determined in genetic horizons in relation to moisture content (Profile 2013), virgin land.

Curve 1 - determination of hardness and moisture on Aug. 13; Curve 2 - on Sept. 5; Curve 3 - on Sept. 13; Curve 4 - on Sept. 28; Curve 5 - before irrigation.

odel (21) hardness gage. This gage consists a rod 50 cm long and a cylindrical plunger cm² in cross sectional area. The soil is leached, meadow chernozem containing fine ay loam. The A + B_1 horizon is 50-60 cm ick (1). The humus content was 7%-12%. igure 4 shows the difference in the hardness the soil when plowed deeply without a moldoard (curve 1) and when plowed in the usual anner with a moldboard (curve 2).

It can be seen that the soil, having been under crop rotation (curves 3 and 4) and having been worked at the surface, rapidly compacts after deep plowing (curves 5 and 6). The fourth year after it had been in crop, it reaches the hardness of sodded virgin land (curve 8) after deep plowing. When T. S. Mal'tsev's method of cultivation is used, a sharp increase in soil hardness and, consequently, density is noted from the beginning to the end of the rotation. Under normal cultivation, or annual plowing to a depth of 20-22 cm, the range of soil hardness and density variations is two times as small from spring

Table 1

Dynamics of hardness of different genetic horizons of various soil groups in the Kutuluk solonetz depression. V. P. Goryachkin's hardness gage ("penetratometer"). Cylindrical plunger 2 cm² in cross section. Hardness expressed in kg per square cm.

Soil and land use	Date of test	Depth at which hardness was measured, cm									
		5	10	15	20	25	30	35	40	45	50
		A^{x}_{plowed} 0—20				A_1 20—32		B_1 32—45			
Terrace fine clay loam ordinary chernozem, slightly eroded stubble. Profile 2003	10.IX[a]	$\frac{8{,}5}{12{,}0}$[b]	$\frac{17{,}0}{8{,}5}$	$\frac{21{,}0}{8{,}0}$	$\frac{21{,}0}{18{,}5}$	$\frac{31{,}0}{10{,}0}$	$\frac{35{,}5}{12{,}0}$	$\frac{32{,}0}{12{,}0}$	$\frac{43{,}0}{12{,}0}$	$\frac{50{,}0}{12{,}0}$	$\frac{45{,}5}{12{,}0}$
	10.IX	$\frac{8{,}0}{25{,}0}$	$\frac{13{,}0}{24{,}5}$	$\frac{14{,}5}{22{,}0}$	$\frac{20{,}0}{18{,}0}$	$\frac{22{,}0}{15{,}0}$	$\frac{26{,}0}{12{,}5}$	$\frac{30{,}0}{12{,}0}$	$\frac{46{,}0}{12{,}0}$	$\frac{46{,}0}{12{,}0}$	$\frac{56{,}0}{12{,}0}$
	21.XX	$\frac{18{,}0}{18{,}8}$	$\frac{19{,}5}{19{,}5}$	$\frac{19{,}2}{19{,}5}$	$\frac{19{,}2}{18{,}0}$	$\frac{21{,}0}{16{,}0}$	$\frac{28{,}0}{13{,}0}$	$\frac{31{,}5}{12{,}0}$	$\frac{31{,}5}{12{,}0}$	$\frac{31{,}5}{12{,}0}$	$\frac{46{,}0}{12{,}0}$

Table 7 continued

Soil and land use	Date of test	Depth at which hardness was measured, cm									
		5	10	15	20	25	30	35	40	45	50
		A_{plowed} 0–20				A_1 20—35		B_1 35—45		B_2 45—50	
Terrace fine clay loam ordinary chernozem, weakly solonetzed May fallow. Profile 2014	29.VIII[a]	0,5[b]/5,0	0,5/8,0	0,5/10,0	6,5/11,0	27,0/12,0	32,0/12,5	34,0/12,5	32,5/12,5	34,0/12,0	35,0/12,5
	6.IX	0,5/19,0	0,5/13,0	0,5/11,0	0,5/11,5	30,5/12,5	28,0/12,0	30,0/12,0	34,0/12,0	34,0/12,0	38,0/12,0
	17.IX	2,0/23,5	3,0/24,0	3,0/24,0	6,5/24,0	10,0/23,5	12,0/20,0	23,5/15,0	34,5/13,0	40,0/11,5	40,0/11,5
	10.X	3,5/27,0	3,0/26,0	3,0/24,0	6,0/21,0	17,0/18,0	23,0/16,0	28,0/15,0	35,0/13,0	37,0/12,0	39,5/12,0
		$A_0$0–4	A_1 4—20			B_1 20—37		B_2 37—50			
Chernozem-like fine clay loam meadow soil. Virgin land. Profile 2007	28.VIII[a]	36/5	43/7	45/8	51/9	60/10	Spring was compressed to the limit				
	30.VIII	14,0/24,0	16,0/21,0	13,5/20,0	13,5/20,0	18,0/18,0	18,0/11,5	18,5/10,0	—/10,0	—/10,0	10,0
	5.IX	19,0/21,0	26,0/19,0	27,0/17,0	27,0/16,0	26,0/15,0	24,0/15,0	24,0/14,0	24,0/13,0	24,0/13,0	24,0/13,0
	13.IX	22,0/17,0	22,0/20,0	9,0/20,0	27,0/19,0	60,0/16,0	Spring was compressed to the limit				
	27.IX	15,5/8,0	36,0/11,5	50,0/14,5	49,5/16,2	48,0/18,0	51,0/19,0	43,5/19,5	42,0/20,5	42,0/20,0	42,0/20,0
		A_{04}	B_1 4—17			—	—	—	—	—	—
Crust-columnar fine clay loam solonetz. Virgin land. Profile 2008	28.VIII[a]	34[b]/5	45/8	62/9	—	Spring was compressed to the limit					
	31.VIII	4,0/22,0	6,0/26,0	56,0/25,5	64,0/13,0	"					
	5.IX	13,0/20,5	4,5/21,0	48,0/18,0	56,0/17,0	"					
	13.IX	12,5/15,0	7,0/14,5	56,0/13,5	64,0/10,5	"					
	28.IX	22,0/18,5	16,5/17,0	20,0/15,0	56,0/13,0	"					
		Layer 1, 0—10		Layer 2, 10—38						Layer 3, 38—50	
Takyr-like fine clay loam solonetz-solonchak. Virgin land. Profile 2013	28.VIII[a]	42/5	41/7	38/10	39/12	40/14	40/14	55/14	60/14	60/14	—
	31.VIII	0,5/21,0	30,0/12,0	56,0/9,0	Spring was compressed to the limit						
	5.IX	9,5/14,5	37,0/12,0	46,0/11,5	44,5/12,5	46,0/12,0	46,0/12,0	Not det'd.			
	13.IX	7,0/15,0	19,0/13,0	46,0/11,0	44,0/10,5	46,0/11,0	42,0/11,5	38,0/12,5	42,0/11,5	48,0/11,0	54,0/11,0
	27.IX	17,5/14,0	28,0/11,0	48,0/9,5	60,0/10,0	Spring was compressed to the limit					

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[a] Before irrigation; later dates — after irrigation.

[b] Numerator stands for hardness; the denominator, for soil moisture content.

Note: Comma represents decimal point.

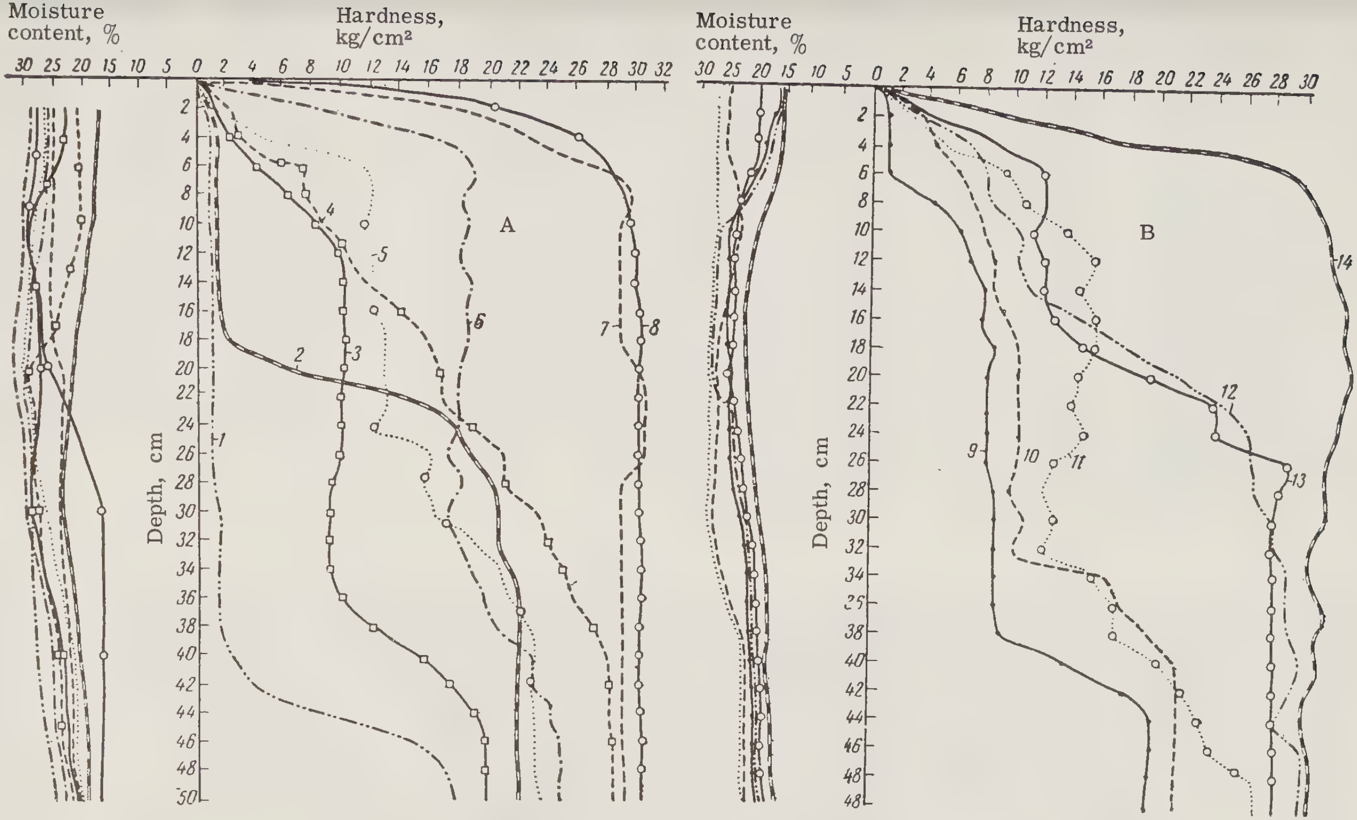

Fig. 4. - Variations in soil hardness depending on the method of cultivation (0-50 cm).

A - Shadrin experimental station; Curve 1 - deep plowing without moldboard (Profile 166); Curve 2 - normal May fallow (Profile 167); Curve 3 - wheat on deep fallow (Profile 154); curve 4 - wheat on normal fallow (Profile 153); Curve 5 - wheat in a field disc-harrowed for the 1st year (Profile 306); Curve 6 - oats with vetch in a field disc-harrowed for the 2nd year (Profile 176); Curve 7 - oats in a field disc-plowed field the 3rd year (Profile 159); Curve 8 - virgin land in a forest opening (Profile 116); B - Kurgans experimental station. Curve 9 - deeply plowed without a moldboard; Curves 10 and 11 - wheat on black fallow deeply plowed in spring without moldboard; curves 12 and 13 - wheat on plowed black fallow and under winter fallow; Curve 14 - wheat in a field disc-harrowed for the 4th year.

to summer, and the hardness value itself is two times smaller than under two-or three-year old crops sown on disc-harrowed field.

A similar dependence of soil hardness and method of cultivation is found for the meadow-steppe leached, medium clay loam chernozem of the Kurgansk experimental station, which can be seen from Figure 4B. These soils contain less humus (about 6%-8%) than those at Shadrin station.

Large differences were noted in the hardness of soil with deeply plowed fallow and under wheat (curves 9, 10 and 11). At the Kurgan experimental station the soil is loosened once, instead of twice as at the Shadrin station and the hardness of soil after the 4th year of crop rotation on non-plowed harrowed soil (curve 14). The hardness of the soil in a field with spring crops after fall plowing and in normal fallow (curves 12, 13) is medium and practically does not change from year to year, which creates more stable conditions for agricultural crops and for various methods of cultivation.

It was noted in 1953 that the normal (20-22 cm) deep plowing and disc harrowing to a depth of 6-8 cm of a perennial grass sod had different effects on soil hardness, not only on the quickly drying upper horizons, but also on the underlying horizons. After normal plowing the soil is less hard and more moist than after disking.

We noted that, when fields were disc-harrowed, only without plowing prior to sowing, many spots with yellowed wheat plants appeared. In order to determine the causes of this phenomenon, we measured the hardness of the soil in various parts of the field to a depth of 15 cm by means of Ryvkin's (21) small hardness gage, with a plunger 1 cm² in cross sectional area. It was found that where plants developed poorly, the hardness of the soil increased to such limits that the hydrological and physical properties of the soil deteriorated. Where the plants were in good shape, the soil was some times twice less hard than under the spots with the wilted plants.

These data were obtained from soil hardness measurements repeated 100 times, and confirmed by investigations in many fields. We may be told that poor plant growth may also be caused by other, more basic, physiological factors as, for instance, solonetzic soil, uneven precipitation distribution on a field which is tilled to a shallow depth, so that the role of microrelief in the distribution of precipitation increases, etc. We do not deny this, however, the foregoing factors affect an increase in soil hardness, thus further aggravating the unfavorable conditions for plant growth.

Conclusions

1. We used a physical-mechanical approach in evaluating the genetic and agricultural properties of soil.

2. A high reciprocal correlation was found between the hardness and moisture content of the soil, i. e., a decrease in hardness with an increase in moisture, as measured in individual genetic horizons. The correlation coefficient for the A_1, B_1, B_2 and B_3 horizons reaches, in the majority of cases, 0.90, 0.95 and even, in certain cases, 0.99, which indicates that the correlation is close to a functional dependence.

3. Terrace ordinary chernozem in the Middle Volga region (Kutulsk), meadow-steppe chernozem and meadow-chernozem-like soil of Kurgan Oblast' have the lowest hardness, which ranging in the plowed layer when its moisture content is 8%-25%, from 2-30 kg/cm² (after being plowed and when compacted). Then follow chernozem-like solonetzic soil and solonetzic chernozem. (Kutuluk), the hardness of which in the dry state may reach 50 kg/cm².

The hardest soils are solonetz-solonchak and, especially, crust-columnar solonetz. The hardness of the columnar layer of the latter at a moisture content of 10%-15%, reaches 60 kg/cm² and more.

4. It was noted that excessive hardness has a depressive effect on the development of plants.

It is estimated that during the initial phases of growth of grain crops, the hardness of the soil should not exceed 5-8 kg/cm² when the moisture content is between 18% and 25%, while in the middle of the growing season, when the moisture content is somewhat lower, it should not exceed 20-25 kg/cm². A hardness of more than 25-30 kg/cm² must be considered harmful to plants. A very hard soil accumulates and stores less precipitation than a soil of medium hardness.

For cultivated row crops the hardness of the plowed layer should not exceed 5-8 kg/cm² during the entire growing period.

5. It is recommended that hardness gages be used at experimental stations of kolkhozes and sovkhozes for control observations on various methods of soil cultivation and plant care.

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BIBLIOGRAPHY

1. AFANAS'YEVA, YE. A. and P. U. BAKHTIN. 1958. Problem of classifying soils intermediate between meadow soil and chernozem in the forest-steppe zone of the West Siberian Plain. Pochvovedeniye, No. 7.

2. BAKHTIN, P. U. 1954. Dynamics of the physical and mechanical properties of soil in relation to cultivation problems. Trudy Pochvennogo instituta im. V. V. Dokuchayeva Akad. Nauk SSSR. Vol. 45.

3. BUROMSKIY, V. I. 1957. Selection of caps of appropriate size and shape for portable density gages. Doklady Vsesoyuznogo ordena Lenina akademii sel'skokhozyaystvennykh nauk imeni V. I. Lenina, No. 4.

4. VYSOTSKIY, A. A. 1954. Dynamometric measurement of agricultural machines. Moscow.

GOLUBEV, I. F. 1935. Study of soils during traverses. Izvestiya Vsesoyuznoy akademii sel'skokhozyaystvennykh nauk imeni Lenina.

GORBUNOV, N. I. and N. YE. BEKAREVICH. 1955. Soil crust forming during the irrigation of cotton.

DOLGOV, S. I. 1936. Soil resistance to loosening; its agronomical significance and methods of measurement. Transactions of the conference of young scientists on the problems of fertilizers, agricultural techniques and agricultural soil science, Tekhnicheskaya Sel'skokhozyatstvennaya Akademiya.

DOLGOV, S. I. 1940. Establishing the plantations in Talysh. 1940. Sovetskiye subtropiki. No. 3.

ZHELIGOVSKIY, V. A. 1952. Wheel tracks and the mechanics of wheel rolling. Sbornik Trudov po zemledel'cheskoy mekhanika. Sel'khozgiz.

KACHINSKIY, N. A. 1931. Study of the soil physical properties of soil and plant root systems during the regional soil investigations. Moscow.

KACHINSKIY, N. A. 1934. Experience in the agricultural-meliorative description of soils. Part I. Moscow, Izdatel'stvo sovetskoy sektsii MAP.

KACHINSKIY, N. A. 1937. Properties of the soil as a factor determining working conditions for agricultural machines. Pochvovedeniye, No. 8.

KACHINSKIY, N. A. 1939. Determining the specific resistance of soil during plowing from its resistance to cleavage. Pochvovedeniye, No. 9.

KACHINSKIY, N. A. 1958. Texture and micro-aggregate composition of soil and methods of study. Izdatel'stvo Akad. Nauk SSSR.

15. KEEN, B. A. 1933. Physical properties of soil. (Translated from English by V. P. Zhnze and I. Yu. Nelidov; Edited by A. F. Ioffe). GTTI.

16. KIVADZE, V. V. 1937. Factors affecting specific soil resistance. Mekhanizatsiya sotsialisticheskogo sel'skogo khozyaystva. No. 10.

17. KIKVADZE, V. V. 1948. Methods of differentiating planned production norms and fuel consumption for agricultural operations by tractors. Saratov.

18. KOCHERINA, YE. I. Physical properties of soils on the terraces of the Kutuluk River. 1952. In: Trudy Pochvennogo instituta im. V. V. Dokuchayeva, Akad. Nauk SSSR. Vol. 37.

19. MOROZOV, D. F. 1940. Determining the specific resistance of soil with Goryachkin's penetratometer. Mekhanizatsiya i elektrifikatsiya sotsialisticheskogo sel'skogo khozyaystva. No. 7.

20. NOVIKOV, P. M. 1952. Terrace soils of the Middle Tram-Volga region, their genesis and evolution. Trudy Pochvennogo instituta im. V. V. Dokuchayeva Akad. Nauk SSSR. Vol. 37.

21. REVYAKIN, YU. YU. 1945. Construction of tractor dynamometers and soil penetratometer for field measurements at Motor-tractor service and supply stations and in sovkhozes. Doklady Techicheskoy Sel'sko khozyaysturnnoy Akademii, No. 11.

22. SHCHUKIN, N. V. 1937. Physical properties of soil and the traction of plows. Sel'skokhozyaystvennaya machina. No. 3.

23. SHCHUKIN, N. V. 1940. Physical and mechanical properties of soil and the force of plows. In the collection: "Cultivating machines," Vol. 3. Narodnyy komissariat tyazhelogo machinostroyeniya, Mashgiz.

CLASSIFICATION OF ALLUVIAL SOILS OF THE VOLGA-AKHTUBA FLOOD-PLAIN AND THE VOLGA DELTA

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In relation to the problem of the agricultural reclamation of the land in the Volga-Akhtuba flood-plain and the Volga delta, the Southern State Institute for the Planning of the Water Economy and Meliorative Construction began soil-melioration investigations with the object of compiling a large-scale soil melioration map of the Volga-Akhtuba flood-plain and the Volga delta. The results of the investigations will be used for assessing the land which can be reclaimed in this area, for selecting areas to be irrigated, and for substantiating and working out a rational system of meliorative and agricultural practices.

The soils of the Volga-Akhtuba flood-plain were studied by many investigators (1, 2, 8, 10, 11). However, there is no unified classification of these soils to this day, which makes the soil melioration investigations and the use of the material obtained in earlier work difficult.

The flood-plain soil classification submitted for discussion was compiled[1] on the basis of soil melioration investigations conducted by the Southern State Institute for the Planning of the Water Economy and Meliorative Construction from 1958-1959 on a series of key areas in the Volga-Akhtuba flood-plain and the Volga delta. Work conducted previously by various investigators in this area was taken into account.

The subdivision of salinized soils into

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[1] At the consultation and approval of Ye. N. Ivanova.

Table 1

Classification of flood-plain saline soils of the Volga-Akhtuba flood plain and the Volga delta

Division of soils by the depth at which salt was found	Depth at which salts were found	Division of soils by the magnitude of the solid residue	Solid residue, %
Solonchaks	Salts from the surf. to 5 cm	Solonchaks	> 1,5
Soils solonchak-like at the surface	Salts at a depth from 5-30 cm	Weakly solonchak-like at surface	0,25—0,5
		Moderately solonchak-like at the surface	0,5—1
		Strongly solonchak-like at the surface	1—1,5
Solonchak-like	Salts at a depth from 5-30 cm and deeper	Weakly solonchak-like	0,25—0,5
		Moderately solonchak-like	0,5—1
		Strongly solonchak-like	> 1
Solonchakized	Salts at a depth from 30-80 cm.	Weakly solonchakized	0,25—0,5
		Moderately solonchakized	0,5—1
		Strongly solonchakized	> 1
Deeply solonchakized	Salts at a depth from 80-150 cm	Deeply weakly solonchakized	0,25—0,5
		Deeply moderately solonchakized	0,5—1
		Deeply strongly solonchakized	> 1

Note: Comma represents decimal point.

ieties according to the depth at which water-
uble salts were found and the degree of
inization (saline horizons) was performed on
basis of a classification worked out es-
cially for the conditions of the Volga-Akhtuba
od-plain and the Volga delta (Table 1). Soils
h a solid residue of less than 0.25% at a
oth from 0-150 cm (along individual horizons
lithological layers) belong to not salinized
ls.

We recommend that the degree of saliniza-
n of individual saline horizons be first de-
mined visually in the field from the amount
visible water-soluble salts. The accepted
ual subdivision according to the degree of
inization, for instance of solonized soils, is
following: a) weakly solonchakized—salts at
epth from 30-80 cm in the form of individual
all spots and streaks; b) medium solonchak-
d—salts at a depth from 30-80 cm in the form
numerous spots, streaks and efflorescences;
strongly solonchakized—salts at a depth from
-80 cm in great amounts and in all morpho-
ical forms.

Visual determinations are periodically
ecked against analyses. The type of saline
ls, parent materials and ground waters is
ermined on the basis of Lebedev's classifica-
n (9).

Depending on the content of adsorbed sodium
cording to Antipov-Karatayev), the soils are
divided into non-solonetzized (less than 5%
exchangeable sodium of the total adsorbed
ions) weakly solonetzized (5%-10%), medium
onetzized (10%-15%) and strongly solonetz-
d (15%-20%).

The soils are subdivided according to texture
conformity with the widely-accepted classifica-
of Kachinskiy (7), based on the texture of the
er 0.5 m of the soil profile. If the texture
ies in this layer, the designation of the soil
sists of two terms (for instance, medium
loam on sand). The first term relates to
texture of the upper part of the profile (the
er genetic horizon, or the plowed layer), and
second, to the underlying genetic or litholo-
l horizons (under the plowed layer). Data on
texture of the 50-100-cm, 100-150-cm and
-200-cm layers are shown for the given
ers in the form of individual lithological maps.

The accepted division according to the degree
oisture and the distribution of gley horizons
g the profile is the following.

A. Surface wetting

) surface-water gley—gleyed from the sur-
down to a depth of 80 cm;

) surface-water gleyized—gleyed from the
ace down to a depth of 30 cm;

) surface-water deeply gleyized—gleyed at
pth from 30-80 cm.

B. Groundwater wetting

) groundwater gley—gleyed from the surface
e ground-water table;

b) groundwater gleyized—gleyed from a depth of 30-80 cm to the ground-water table;

c) groundwater deeply gleyized—gleyed from a depth of 80-150 cm to the ground-water table.

According to the thickness of the humus A horizon (A + B), soils are divided into:

a) very shallow, 10-20 cm;

b) shallow, 20-40 cm;

c) moderately thick, more than 40 cm.

The following three groups of flood-plain soil are distinguished in the area of the Volga-Akhtuba flood-plain and the Volga delta:

I. Flood-plain meadow soil group

Major systematic units (subgroup and genus):

Subgroup 1. Recent alluvial deposits (A_1)
2. Flood-plain alluvial primitive meadow (A_2)
3. Flood-plain alluvial-meadow (A_3)
Genera 1) Flood-plain alluvial-meadow
2) Flood-plain alluvial-meadow solonchakized.
Subgroup 4. Flood-plain forest meadow (FM)
5. Flood-plain meadow dark colored (MD)
Genera 1) Flood-plain meadow dark
2) Flood-plain meadow dark solonchakized
3) Flood-plain meadow dark solonetzized
Subgroup 6. Flood-plain meadow dark stratified (MDS)
Genera 1) Flood-plain meadow dark stratified
2) Flood-plain meadow dark stratified solonchakized
Subgroup 7. Flood-plain meadow dark steppe-affected (MDSt)
Genera 1) Flood-plain meadow dark steppe-affected
2) Flood-plain meadow dark steppe-affected solonchakized.

Recent alluvial deposits (A_1) are located along the Volga and Akhtuba Rivers and occupy the youngest portions of the flood-plain, such as sand bars and beaches. In the Volga delta recent deposits are located in the peripheral portions of young islands and seashore ridges. The morphological indices of the recent alluvial deposits are stratification, loose consistence and the absence of even the most slightly developed surface humus horizons. There is no vegetation. Texturally these deposits are sandy loam and sandy.

When vegetation becomes established on recent alluvial deposits they evolve into flood-plain alluvial primitive-meadow soils.

Flood-plain alluvial primitive-meadow soils (A_2) were formerly called alluvial-accumulative (11), alluvial-stratified (10) and poorly developed meadow soils (1). They are distributed along river banks in the portion of the flood-plain near the river and elevated areas at the periphery of islands in the delta under sedge-grass vegetation (sedge, cinquefoil, licorice, and others). The ground-water table during its low period is located at a depth of 3-4.5 m.

The major morphogenetic indices are: there is no differentiation into genetic horizons; the humus A horizon is light-gray, structureless, up to 10 cm thick and changes abruptly into stratified alluvium of a corase texture; sod is either nonexistant or poorly defined; the soils do not effervesce and are not salinized; the humus content in the A horizon varies from 1.5% -0.5%. Texturally this soil is sandy and sandy loam. Under the influence of grasses this soil evolves into flood-plain alluvial-meadow soil (1).

Flood-plain alluvial-meadow soils (A$_3$) were formerly called meadow (10), accumulative-sod (11) and meadow-sod stratified soil (1). They are found in the small-ridge central flood-plain, on the ridges of the large-ridge flood-plain near the river and in elevated areas of islands in the delta under grass-mixed herb vegetation (couch grass, brome, spurge, licorice and others). Brome is not found on saline soils in the flood-plain and in the delta. The ground-water table during its low period is located at a depth of 2.5-3.5 m. The principal morphogenetic indices are: the humus A horizon, 10-40 cm thick, is characterized by a gray, light-gray, grayish-brown color and a blocky, silty-blocky and sometimes blocky-granular structure. Sod is more or less developed from the surface down. The humus content in the A horizon is 1.5%-2.5%. The humus horizon abruptly (but not always) changes into stratified alluvium of varying texture. Buried humus horizons are frequently found. These soils sometimes contain carbonates in the form of concretions or white specks at a depth below 0.5 m. Carbonate accumulations effervesce in places. The texture of the humus horizon is that of coarse and medium clay loam and rarely fine clay loam. The total exchangeable cations in the humus horizon varies from 15-40 meq. The soil adsorption complex is saturated with calcium and magnesium. The ratio of calcium to magnesium in the upper horizon is from 4-5.

Flood-plain alluvial-meadow solonchakized soils contain salts at various depths in the form of efflorescences and interlayers. These soils are subdivided into strongly solonchakized, solonchakized, and solonchak-like at the surface. They evolve into flood-plain meadow dark soils (1).

Flood-plain forest-meadow soils (FM) were formerly called meadow-sod-forest soils (1). They are found on the ridges of the large-ridge peripheral flood-plain and elevated areas at the periphery of the central valley and gently sloping ridge flood-plain under forests of the park type with a thick herb vegetation. Forest vegetation is represented primarily by oaks and elms and meadow vegetation by couch grass, brome and others. The ground-water table during its low period is found at a depth of 3-4.5 m.

The soils have a characteristic dark-gray A horizon up to 20 cm thick with a well-defined granular, granular-nutty, blocky-granular structure and a cinnamon-brownish-gray (dark gray) B horizon up to 50 cm thick with a blocky-nutty structure changing into stratified alluvium of a coarse texture. The humus content in the A horizon is 3%-7% and that in the B horizon, 2%-3%. There is no effervescence and salinization along the entire profile. The adsorption complex of the soil is saturated with calcium and magnesium. The ratio of calcium to magnesium in the humus horizon varies from 4-5. Texturally these soils are clay loams and clays.

Flood-plain meadow dark soils (MD) were formerly called granular sod-meadow (11), sod-meadow (10) and dark meadow (1) soils. They are found on ridges and ridge-like elevations of the gently ridged inner (central) flood-plain and in elevated areas in valleys of the delta under couch grass and brome-couch grass associations. The ground-water table during its low period is found at a depth of 2.5-3.5 m.

The major morphogenetic indices of these soils are: a profile clearly differentiated into genetic horizons. The humus A horizon, which is up to 25 cm thick, is characterized by a dark-gray color and a granular, blocky-granular structure. There is 3-8 cm thick sod at the surface. The humus B horizon is dark-gray, sometimes with a brownish tinge, of a blocky, blocky-granular, and blocky-nutty structure gradually changing into the grayish-brown C horizon.

The thickness of the humus A + B horizon varies from 35-70 cm. The humus content in the sod varies from 3%-8%, in the A horizon, from 2%-3.5%, and in the B horizon from 1%-2%. The humus content gradually decreases with depth.

These soils usually contain carbonates in their lower part in the form of concretions and diffuse white specks. They effervesce from a depth of more than 0.5 m in places where there are accumulations of carbonates.

The total exchangeable cations in the humus horizon varies from 25-40 meq, depending on texture. The adsorption complex of the soil is saturated with calcium and magnesium. The ratio of calcium to magnesium in the upper part of the profile varies from 3.5-5.

Flood-plain meadow dark solonchak-like soils contain salts in the form of efflorescences and streaks at various depths. These soils are subdivided into strongly solonchakized, solonchakized and solonchak-like soils.

Flood-plain meadow dark solonetzized soils are strongly compacted, fissured and have a well-defined prismatic structure. The adsorption complex of the soil is saturated with calcium, magnesium and more than 5% of the total exchangeable capacity is sodium. The texture of the soil is that of fine clay loam and clay loam.

Flood-plain meadow dark stratified soils (MDS) are found in the inner (central) valley flood-plain (often having a microhilly relief) under asparagus-Heleocharis eupalustris-couch grass and asparagus spurge-couch grass associations. The ground-water table during its low period is located at a depth of 2-3.5 m. The soils are characterized by the presence of sod 2-6 cm thick and a humus A horizon 10-15 cm thick of a dark-gray color and a granular, blocky-granular structure. The A horizon gradually changes into the compact stratified), fissured, dark bluish-gray B horizon 35-70 cm thick with a lumpy or blocky-umpy structure. The profile is weakly gleyed bluish color). The humus content in the sod is up to 4%-7%, that in the humus A horizon, 1.5%-3% and that in the B horizon, 1.5%-1%. The amount of humus gradually decreases with depth. The soils are deeply humified, the humus content at a depth of 1 m reaching 0.8%-0.5%. Carbonates in the form of diffuse white specks and concretions are found in the lower horizons.

The middle part of the profile of these soils s gleyed. The clay fraction (particles <0.001 mm in diameter) in the B and BC horizons reaches 50%-55%. Texturally the soils are coarse clay and clay.

The total exchangeable cations varies in the A horizon from 30-40 meq and in the B horizon from 40 to 50 meq per 100 gm of soil. The adsorption complex of the soil is saturated with calcium and magnesium and contains exchangeable sodium but not more than 5% of the total exchange capacity. In contrast to the meadow dark soils (not stratified), meadow dark stratified soils are characterized by a somewhat higher content of exchangeable magnesium. The ratio of calcium to magnesium in the A horizon varies from 3.5 to 4 and in the B horizon from 3 to 3.5.

Flood-plain meadow dark stratified solonchakized soils contain salts in the form of efflorescences and streaks. They are divided into strongly solonchakized, solonchakized and solonchak-like soils. The strongly solonchakized and solonchakized varieties predominate; solonchak-like soils occur comparatively rarely.

Flood-plain meadow dark steppe-affected soils (MDSt) are found in areas of the flood-plain and the delta which had been banked but not irrigated for 5 to 7 years. Steppe-affected soils are most widely distributed (according to data of Vladychenskiy, [1]) in the area of oxbow lakes near the delta, where the transition to a steppe is associated with a deteriorating moisture regime as a result of the regulation of the Volga River and the displacement of meadow vegetation by steppe vegetation.

Steppe-affected soils are characterized by a lighter color of the humus horizon, compaction and fissuring. As a result of the change from reduction to oxidation processes, the formerly gleyed soil horizons assume the rusty color of ferric hydroxide. The transition to a steppe is accompanied, as a rule, by the mineralization of humus, the accumulation of carbonates and, the supply of mineralized ground water is sufficient, salinization.

Flood-plain meadow dark steppe-affected solonchakized soils contain salts in the form of efflorescences and streaks.

II. Old flood-plain wet-meadow soil group[2]

Major systematic units (subgroups and genera)

Subgroup 1. Flood-plain wet-meadow stratified primitive (MWS^{pr})
2. Flood-plain wet-meadow (stratified) granular gley (MWS^{g})
3. Flood-plain wet-meadow (stratified) gleyized (MWS^{g})
Genera 1) Flood-plain wet-meadow (stratified) gleyized
2) Flood-plain wet-meadow (stratified) gleyized solonchak-like
Subgroup 4. Flood-plain wet-meadow dark granular gleyized (MWD^{g})
Genera 1) Flood-plain wet-meadow dark granular gleyized
2) Flood-plain wet-meadow dark granular gleyized solonchakized
Subgroup 5. Flood-plain wet-meadow dark gley (MWD^{g})
Genera 1) Flood-plain wet-meadow dark gley
2) Flood-plain wet-meadow dark gley solonchakized

Flood-plain wet-meadow (stratified) primitive soils (MWS^{pr}) are found on river banks and on young islands under willow stands. The groundwater table does not drop deeper than 1.5-2 m. The profile is weakly developed. There is either no sod or the sod is weakly developed. The humus content is 0.5%-1.5%. The soils do not effervesce and are not salinized. Texturally they are sandy and sandy loam.

Flood-plain wet-meadow (stratified) granular gley soils (MWL^{g}) are found in depressions between ridges in the large-ridge flood-plain near the river, in the gently sloping ridged and small-ridge inner flood-plain under *Heleocharis*-couch grass and sedge-couch grass associations containing sweet grass, lythrum and tuberous club grass. Soils form under conditions of more or less constantly wet by ground waters. The latter are found at a depth of 1.5-2.5 m during their low period.

The main morphogenetic indices of these soils are: well-developed sod at the surface, 5-10 cm thick; a humus A horizon, 15-35 cm thick, which is characterized by a gray, dark-gray, brown-gray color produced by ochre-rusty spots of iron hydroxide and a powdery-blocky, blocky-granular structure. In moderately thick varieties there is a transitional humus B horizon of a brownish dark-gray color and a blocky, blocky-nutty, granular-nutty structure. The humus horizon changes into gleyed bluish-gray stratified alluvium. The soils are often deeply humified, do not effervesce and are usually not salinized. The humus content in sod is 5%-7%, and that in the A horizon, 4%-2%. The texture of the soil is that of clay loam, fine clay loam, rarely coarse clay loam.

Flood-plain wet-meadow (stratified) gleyized (MWS^{g}) soils are found in the delta in oxbow lakes and depressions between hillocks under couch-grass — *Heleocharis*, — sedge, cattail and reed associations with tuberous clubgrass, lythrum, reedgrass and other mixed herbs. In the flood-plain these soils are found in depressions between ridges.

The soils form under conditions of excessive surface- and ground-water wetting resulting from prolonged flooding and the stagnation of flood water. The ground-water table is located at a depth of 1.5-2.5 m during its low period.

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[2] Earlier this soil group was called Flood-plain-estuary (11) and oxbow-meadow (10,1).

The major morphogenetic indices of these soils are: poorly developed sod at the surface; a gleyed humus A_g horizon of a thickness of 10-30 cm, characterized when wet by a bluish-black, dark-gray color and a nutty-blocky, powdery-blocky, or blocky-lumpy structure. In moderately thick varieities there is a transitional humus B_g horizon.

There is a considerable number of rusty spots of iron hydroxide in the upper part of the profile. As a rule, the humus A_g horizon abruptly changes into less gleyed stratified alluvium of varying texture.

The soil is characterized by a sharp decrease in humus with depth. The A_g horizon contains 2%-4% humus. Shells are often found in deep layers. The soils do not effervesce throughout most of the profile.

Flood-plain wet-meadow (stratified) gleyized solonchak-like soils contain water-soluble salts. They are subdivided into deeply solonchakized, solonchakized, solonchak-like and solonchak-like at the surface. Soils solonchak-like at the surface predominate. The texture of the soils is fine clay loam and clay.

Flood-plain wet-meadow dark granular gleyized soils (MWD^g) are found in flat (and often wide) depressions between the gently-ridged central flood-plain and depressed areas of delta valleys where they form in conditions of continuous ground-water moistening under lythrum and couchgrass—lythrum associations with Hierochloe, horse sorrel and tuberous clubgrass. The ground-water table is found at a depth of 1.5-2.0 m during its low period.

The soils are characterized by well-developed sod, 5-10 cm thick, and a dark-gray humus A horizon, 20-30 cm thick, of a granular or blocky-granular structure. The transitional humus B_g horizon is 35-60 cm thick, has a dark-gray color with a bluish tinge and a blocky-granular or blocky-nutty structure. There are rusty spots of iron hydroxide in the profile. The lower horizons of these soils (BC_g and C_g) are gleyed, as a rule, and sometimes contain carbonates in the form of concretions and diffuse white specks. The soils do not effervesce throughout most of their profile.

The humus content in the sod is 8%-14.5%, in the A horizon, 3%-4% and in the B horizon, 1%-2.5%. The soils are deeply humified. They are saturated with calcium and magnesium and sometimes contain exchangeable sodium, but not more than 5% of the total exchange capacity. They are fine clay loam and coarse clay in texture.

Flood-plain wet-meadow dark granular gleyized solonchakized soils contain salts in the form of efflorescences and streaks. They are subdivided into deeply solonchakized, solonchakized, solonchak-like and solonchak-like at the surface.

Flood-plain wet-meadow dark gley soils (MWD^g) are found in deep depressions between ridges in the gently-ridged central flood-plain, depressed areas in valleys near the river and oxbow lake depressions in the delta. They form in conditions of excessive wetting resulting from the stagnation of flood water at the surface under Heleocharis, sedge, Heleocharis — sedge, and reed associations with lythrum, tuberous clubgrass, flowering rush, and other mixed herbs. The ground-water table is found at a depth of 1.0-2.0 m during its low period.

The soils are characterized by poorly-developed sod, 5 cm thick, and a humus A_g horizon, 15-20 cm thick, which is bluish-gray (dark gray) in color with rusty spots of ferric hydroxide, and of a powdery-blocky, sometimes powdery-granular or blocky-lumpy structure. The transitional humus B_g horizon, up to 40 cm thick, is gleyed, as a rule, and is of a bluish-black color. The structure of the B horizon is blocky, blocky-nutty, or lumpy. The humus content in the sod varies from 5%-8%, that in the A_g horizon, from 3%-4% and that in the B_g horizon, from 1.5%-1%. The soils are characterized by a sharp decrease of humus with depth. The adsorption complex of the soil is saturated with calcium and magnesium; the content of exchangeable sodium does not exceed 5% of the total exchange capacity. The soils are fine clay loam and coarse clay loam.

Flood-plain wet-meadow dark gley solonchakized soils contain salts in the form of efflorescences and streaks. They are subdivided into deeply solonchakized, solonchakized, solonchak-like and solonchak-like at the surface.

III. Flood-plain bog soil group

Major systematic units (subgroups and genera

Subgroup 1. Flood-plain clay-bog
Genera 1) Flood-plain clay-bog (B)
2) Flood-plain clay-bog solonchak-like at the surface.

Flood-plain clay-bog soils (B) are found in oxbow lakes, water bodies overgrowing with vegetation and excessively moist depressions under reeds, reed-cattail and cattail associations, frequently mixed with arrowhead and flowering rush (in the flood-plain). The soils form under conditions of continuous excessive surface- and ground-water wetting. The ground-water table does not drop below 1 m during its low period.

The major morphogenic indices of these soils are: remains of semi-decomposed and undecomposed bog vegetation at the surface; a humus A_g horizon which is gleyed, as a rule, and characte ized by a poorly defined blocky and sometimes powdery-granular structure. The humus content in the A_g horizon varies from 2%-4%. The amount of humus sharply decreases with depth. These soils do not usually effervesce.

The total exchangeable cations in the humus horizon reaches 40-50 meq/100 gm. The adsorption complex of the soil is saturated with calcium and magnesium and sometimes contains sodium, but not in excess of 5% of the total exange capacity.

Flood-plain clay-bog soils which are solonak-like at the surface contain efflorescences water-soluble salts in the layer from the rface to 30 cm down. These soils are finetured, fine clay loam and clay.

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BIBLIOGRAPHY

. VLADYCHINSKIY, S. A. 1954. Genesis of soils in the Volga-Akhtuba flood-plain and the Volga delta. Pochvovedeniye, No. 9.

. GUDKOV, M. P. and YE. A. MICHAYLOV. 1951. Regional description of soils of the Volga delta. Trudy Gosudarstvennogo Okeanograficheskogo Instituta. 18(30). Gidrometeoizdat.

. YEGOROV, V. V. 1958. Scheme for the classification of delta soils in the arid regions of the USSR. Pochvovedeniye, No. 11.

. IVANOVA, YE. N. 1949. Participation of the V. V. Dokuchayev Soil Institute in the work on drought prevention and the reclamation of forest-steppe and steppe regions of the European USSR. Pochvovedeniye, No. 12.

5. IVANOVA, YE. N. 1956. Classification of soils of the northern part of the European USSR. Pochvovedeniye, No. 1.

6. KOVDA, V. A. 1951. Soils of the Volga delta and their place in soil formation. Trudy Gosudarstvennogo Okeanograficheskogo Instituta. 18(30). Gidrometeoizdat.

7. KACHINSKIY, N. A. 1956. Requirement of particle-size analysis and of the classification of soils according to texture. Pochvovedeniye, No. 6.

8. LETUNOV, P. A. 1942. Soils of the Volga-Akhtuba plain and the Volga delta. Collection in memory of V. R. Vil'yams. Moscow–Leningrad. Akad. Nauk SSSR.

9. LEBEDEV, YU. P. 1951. Problem of the classification of saline soils. Doklady Akad. Nauk SSSR. 31(5).

10. MIKHAYLOV, YE. YA. 1951. Explanatory note to the soil map of the Volga delta and oxbow lakes near the steppes. Trudy Gosudarstvennogo Okeanograficheskogo Instituta. 18(30). Gidrometeoizdat.

11. PLYUSNIN, I. I. 1938. Soils of the Volga-Akhtuba flood-plain. Stalingrad.

12. SHRAG, V. I. 1953. Experimental classification of flood-plain soils. Poch., No. 11.

CHARACTERIZATION OF THE PRESENT SALINE SOILS IN THE TEREK RIVER DELTA[1]

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The delta of the Terek River is an important agricultural area in the Northern Caucasus, which has good possibilities for the development of viticulture, horticulture, field crops and animal husbandry. However, the land of the delta has been little utilized to this day. For instance, of the 1600 km² surveyed in the area of the Old Terek irrigated system, only 15%-20% is used under agricultural crops. The rest of the area is virgin land or abandoned and layland. The area of the Terek delta near the sea, which is occupied to a great extent by solonchaks and bogs, is especially little reclaimed. All these lands are most often used for pasture and in a small degree for hay.

The natural conditions in the Terek delta are such that agriculture is concentrated almost exclusively on irrigated lands and still is of the layland type. As the soils become more salinized and water-logged, all new areas are put under irrigation. Cultivated soils are primarily put under grain crops.

A very insignificant portion of the area is occupied by industrial crops, gardens and vineyards. For instance, a survey made by kolkhozes in 1955 shows that within the area of the Old Terek irrigation system 70% of the plowed area is occupied by grain crops, 10% by industrial crops, 7% by forage crops, 3% by vegetables, 7% by gardens and less than 1% by vineyards.

In spite of irrigation, yield is generally low. In the comparatively good crop year of 1955 the yield of winter wheat averaged 13 cntr/ha, that of corn, 4.3 cntr/ha, that of sunflower, 3.7 cntr/ha, that of potato, 35 cntr/ha, and that of grapes, 35.3 cntr/ha. It should be noted that the yield varied for individual farms by 500%-1000%.

One of the main reasons for low yield and the low development of agriculture in the Terek delta is the salinization and water-logging of soils. The development of these processes is caused on the one hand by the natural conditions of the delta and on the other hand by the nature of the existing irrigation farming.

Certain Characteristics of Soil Formation in the Terek Delta

Soil formation in the Terek delta, as in many other coastal deltas, is closely associated with the geological activity of rivers and the sea. As known, the Terek River carries a great amount o sediment which settles for the most part in the delta. As a result of the accumulation of alluvial deposits, the beds of active catchments become unstable. During severe floods, the water breach the river banks and streams change cour The old drainage pattern disappears and a new pattern forms in another area.

This process is superimposed by the transgressions and regressions of the Caspian Sea. The advance of the sea caused a rise of the ground waters, an increase of their mineralization and the intensification of the salinization of soils. The retreating sea left numerous solonchak lagoons and lakes, which to this day serve as the main source of salinization in the coastal zone of the delta.

The influence of the river and the sea on the soil manifested itself primarily in the absolute age of the soils and the degree of their salinization. S. V. Zonn (1) distinguishes the following stages of soil formation in the Terek delta: shoals → bog → meadow → light chestnut. In addition, a transition from meadow soils to solonchaks often occurs according to the following scheme: meadow (or bog) soils → meadow solonchak-like soils → solonchaks. In the coastal zone, where salt accumulation was especially intense, solonchaks often assume the appearanc of takyrs (dry) when the ground water is below the critical level.

It must be noted that the development of soil according to the first scheme with the formation of light-chestnut soils is not typical for the Terek delta. Actually meadow soils are in various stages of becoming steppe-like. Even if soils are found which are similar to light-chestnut soils they are so non-typical that they uld be called young or primitive. The last dition indicates that the absolute age of the a soils is comparatively small.

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[1] The article was written on the basis of data of soil melioration investigations in 1954 by the Branch of the Southern State Institute for the Planning of the Water Economy and Meliorative Construction under the supervision of the author in relation to the development of a project for the reconstruction of the Old Terek irrigation system.

Three soil regions are distinguished in the ek delta according to the characteristics of soils: 1) central-delta, 2) alluvial-mari- e, and 3) coastal (Fig. 1).

Central-delta region occupies the upper part he delta. In this region the upper layer of materials to a depth of many tens of meters sists exclusively of material of alluvial ori- Therefore, it may be called the region of vial deposits.

Three sub-regions are distinguished in the a of the Old Terek irrigation system ac- ding to the relative age of the drainage tern: New-Terek, Old-Terek and Kuru- ek (Table 1).

New-Terek sub-region is one of the youngest ions. It is still under the influence of flood ndations to this day. At this time a consider- e surface layer of fresh alluvial deposits accumulated here, on which young primitive alluvial-meadow and bog soils form. Salinization of ground water is least in this region. The mean content of salts in the upper 1 m is <0.5% (in solid residue). The area occupied by solonchaks does not exceed 5%.

In the Old Terek sub-region the upper layer of soil material has not been renewed for a long time. Water flow is kept up by engineering methods. This area has been under irrigation for a long time. The soils are predominantly meadow soils of varying degrees of salinization. Solonchaks and solonchak-like varieties occupy about 10% of the area. The mean area occupied by continuous solonchaks does not exceed 100 ha. An average of 1%-1.5% of salts is contained in the upper 1 m.

Kuru-Terek sub-region is the oldest as far as the age of surface deposits is concerned. There is no active drainage pattern. Only old beds and streams are encountered. This region has been under irrigation the longest. In addition to meadow soils, a large area is occupied here by steppe-like meadow soils and soils undergoing transition to the chestnut group. The salinization of soils is higher. The salt content

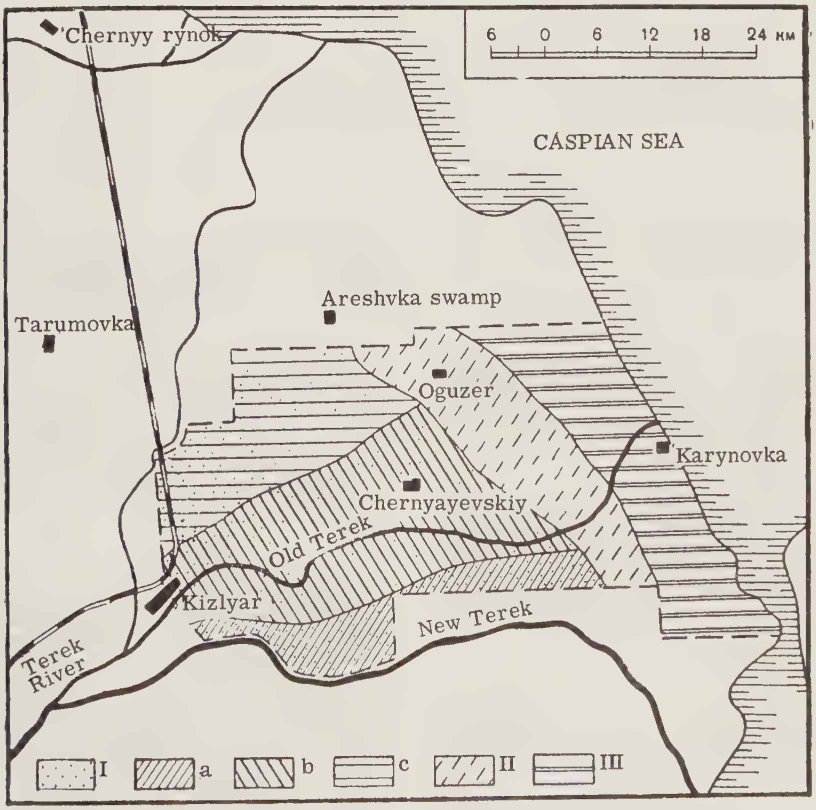

Fig. 1. - Scheme of the soil melioration regions of the area of the Old Terek irrigation system (according to data from the 1:50,000 soil survey conducted by a Branch of the Southern State Institute for the Planning of the Water Economy and Meliorative Construction in 1954).

I - central-delta region; sub-region: a - New Terek, b - Old Terek, c - Kura-Terek; II - alluvial-maritime region; III - coastal region.

Table 1

Principal indices of soil regions in the area of the Old Terek irrigation system

Name of regions and sub-regions	Predominant soil group	Area occupied by solonchaks and solonchak-like soils, %	Average area occupied by continuous solonchaks, ha	Ground water		Mean content of salts in the upper 1 m, % of solid residue
				Level, m	mineralization gm/l	
		Central delta				
a) New-Terek	alluvial-meadow and bog soils	5	—	often <1	1—3	<0,5
b) Old-Terek	meadow soils	11	100	1—3	1—20	1—1,5
c) Kuru-Terek	meadow, steppe-like meadow transitional and chestnut	22	200	1—3	3—50	1—2,0
		Alluvial-maritime				
	transitional to chestnut, solonchaks, meadow solonchak-like soils	51	1000	3—5	20—50	1,5—2
		Coastal				
	solonchaks and meadow solonchak-like steppe-like soils	86	5—10 thous.	about 5	40—50 and more	2 and more

Note: Comma represents decimal point.

in the upper 1 m is 1%-2%. Solonchaks and solonchak-like soils occupy 20% of the area, whereby the mean area occupied by continuous solonchaks is 200 ha.

Alluvial-maritime region is characterized by the development of strongly salinized alluvial-maritime deposits. Solonchaks occupy about 50% of the soil area. The salt content in the upper 1 m is 1.5%-2% and the mean area occupied by continuous solonchaks is about 1000 ha.

Coastal region occupies a belt in the zone under the immediate influence, or which was recently under the influence, of the Caspian Sea. Dry lagoons, containing Caspian fauna in the soil material, are often encountered here. The degree of salinization of the upper 1 m is 2% and more and solonchaks occupy more than 80% of the area. Continuous solonchaks cover an area of 5-10 thousand ha.

The effect of agriculture on soil formation in the delta is expressed primarily in the maintenance of the meadow regime as far as moisture is concerned. The area has been irrigated by "wild flooding" for a long period of time. As a result, the ground-water table is found at such a level that upward capillary flow predominates. Moisture evaporation leads to the concentration of salts in the upper horizons and the intense salinization of soils.

It must be noted that specific soils are found in gardens and vineyards. These soils have a considerably thick humus layer reaching 60-80 cm and a high humus content (3%-5%) as a result of deep cultivation (deep plowing) and fertilization. The humification of the upper and lower soil horizons is similar.

As a result of prolonged exploitation in the absence of natural drainage, these soils are also salinized. Among them areas are sometimes found which by their degree of salinization resemble solonchaks. The mean salinization of the upper 1 m is 0.5%-0.7%. The total area occupied by these soils in the Old Terek irrigation systems is 2000 ha (<1.5%).

Salt Contents in Soils and their Chemistry

The contents of easily-soluble salts in the soils of the Terek delta, which accumulated during the process of delta formation, amount to many millions of metric tons. According to our calculations the salt content in the upper 2 m is 46 million metric tons (1.08% by weight) in the area of the Old Terek irrigation system alone. The degree of salinization of various soils may be judged from Table 2.

As Table 2 shows, the salt contents in various soils vary widely. Weakly salinized and practically not salinized soils contain in their upper 2 m 50-120 metric tons of salt (0.2%-0.5% by weight), moderately salinized soils con tain 150-250 metric tons/ha (0.5%-1%) and solo chaks contain an average of 500-600 metric ton

Table 2

Average saline soils in the area of the Old Terek irrigation system

Soils	Area investigated, km^2	Number of profiles analyzed chemically	Average salt content in the layer, meters						Chloride content in % of solid residue in the layer from 0-2 m
			in %			in metric tons/ha			
			0–0,5	0,5–1	1–2	0–0,5	0,5–1	1–2	
Meadow-bog clay and fine clay loam	75,3	9	0,46	0,47	0,50	29,2	32,0	68,0	14
Meadow solonetz-like and solonchakized clay and clay loam	485,4	122	0,38	0,59	0,69	24,1	39,6	95,2	13
Meadow solonchak-like, predominantly fine clay loam	70,6	29	0,97	1,05	1,16	63,8	71,0	156,6	18
Meadow and alluvial-meadow clay loam, more rarely sandy loam	68,7	5	0,16	0,24	0,43	10,1	16,6	58,7	10
Solonchaks of the meadow group, primarily clay	203,4	60	1,94	1,90	1,50	123,0	127,0	202,0	25
Dry clay and clay loam solonchaks	242,6	68	2,18	2,13	1,72	138,0	143,0	230,0	31
Hilly solonchaks	21,8	10	2,38	2,90	2,08	151,1	195,8	281,0	28
Takyr-like solonchaks	54,8	14	2,31	2,36	2,38	146,5	159,5	321,0	31
Soils under transition to light-chestnut of various textures	261,3	44	0,57	0,96	0,76	36,8	58,5	105,0	22
Deeply cultivated, irrigated clay and clay loams	21,4	36	0,65	0,65	0,55	41,3	43,5	74,2	6
Hilly sands, wind-blown in places	23,1	4	0,30	1,07	1,20	19,0	72,2	162,0	24
Average for each massif			1,03	1,17	1,06	65,4	79,0	143,1	—

lote: Comma represents decimal point.

1.5%-2.5%) in their upper 2 m.

'he chemistry of the salts is primarily as-
ated with the degree of salinization and the
re of the origin of the salts. When the
content is <0.5% (in solid residue) sodium
calcium sulfates predominate, whereby a
iderable amount (often >10%) is represented
alcium bicarbonates. As salinization in-
ses, the proportion of chlorides increases
that of sulfates decreases. The relative
ent of bicarbonates decreases to 1%-2%.
n salinization is at about 3%, chlorides be-
o predominate over sulfates. Among the
ns, the main role is played by sodium; cal-
and magnesium are contained in about the
e amounts.

must be noted that the chloride content
ply decreases in irrigated soils; in the
r 2 m the relative chloride content does not exceed 10%-14%. Chlorides are especially strongly leached from deeply cultivated soils. The content of chlorides in these soils averages 6%-7% of the solid residue (Tables 2 and 3). Under otherwise similar conditions, alluvial deposits contain much less chlorides than soil material of marine origin.

As may be seen from Table 4, marine deposits contain 3-5 times more chloride than alluvial deposits. Approximately the same relation of chlorides is retained in marine deposits with the typical Caspian fauna which are buried under alluvial deposits.

A similar relationship exists between chlorides, sulfates and general mineralization of sea and river water (Table 5).

Thus, the relation between the chemistry of salts accumulated in soil material and the main sources of salinization — river and sea water, may be clearly established.

Type of Salt Balance

The salt balance of the Terek delta, as that of many sea deltas, tends toward salinization. This is primarily due to the stagnation of ground water, the absence of natural drainage and the backing up of ground-water flow by the sea. The large quantities of irrigation and flood water are lost almost entirely on evaporation and transpiration, while the salts they bring remain almost entirely in the upper soil layer. As compared to other sources of salt, this is the largest incoming item in the salt balance. Other sources of salt (atmospheric precipitation, ground water) have no significant effect on the salt balance. According to our calculations, for instance, the possible amount of salt that can be brought by ground water from other areas is less than 2000 metric tons/yr. In the coastal zone impulverization (salt deposition from the atmosphere) may possibly play a role. The annual amount of salt derived from irrigation water and natural inundations in the area of the Old Terek irrigation system is 90,000 metric tons from irrigation water and 10,000 metric tons from inundation water, or a total of 100,000 metric tons.

Taking into account the fact that the area has no outflow, the discharge of salts by ground water is impossible. It takes place most probably by the dissolving of salts by surface water and their discharge into the sea. Such a phenomenon may be observed during the catastrophic flooding of areas occupied by solonchaks. However, as compared with the addition of salts, their loss is very insignificant; according to our preliminary calculations it does not exceed 10% of the income. Thus the annual addition of salts is by 90,000 metric tons higher than the loss.

The annual accumulation of salts in the upper 2 m of soil is 0.2% of the calculated salt contents (46 million metric tons). Naturally, such an insignificant change in the salt contents cannot be determined by direct measurements of the salt content in soils. The increase in the area of saline soils substantiates the previously-mentioned preliminary balance calculations to a certain degree.

As can be seen from Table 6, the area occupied by solonchaks and solonchak-like soils increased by 3% in 22 years, while the area occupied by weakly and moderately salinized soils decreased correspondingly. The annual increment of solonchaks and solonchak-like soils is 0.14%. Thus, the relative growth of salt content and areas occupied by salinized soils is similar.

Local and Seasonal Salt Movements

Local movements of salts along the microrelief and along the soil profile are much more rapid than the process of salt accumulation in the delta, depending on atmospheric precipitation and the irrigation regime. These movements are so great that they can be determined by periodic soil sampling.

The movement of salts along the soil profile only occurs primarily in connection with atmospheric precipitation. The amount of precipitation in the delta is small, the depth of wetting of clay loam, even during the cold period of the year, does not exceed 1 m on the average.

As may be seen from Table 7, the salt content during the winter-spring period decreased only in the upper 0.5 m. An increase of salt was observed in the deeper layers as a result of the influx of salts from above. The total

Table 3

Chemical composition of water extracts from certain profiles of the principal soils in the area of the Old Terek irrigation system, %

Depth, cm	Solid residue	Alkalinity from HCO_3	Cl	SO_4	Ca	Mg	Na by difference
Meadow solonetzic-solonchakized clay soil, Profile 282							
0—18	0,150	0,043	0,036	0,024	0,022	0,004	0,018
18—30	0,187	0,042	0,056	0,030	0,027	0,017	0,003
30—70	0,340	0,034	0,096	0,066	0,038	0,003	0,057
70—120	1,100	0,024	0,190	0,430	0,142	0,050	0,075
140—200	1,338	0,029	0,241	0,638	0,156	0,051	0,197
Solonchak of the meadow-type, clay, Profile 944							
0—9	1,792	0,024	0,868	0,148	0,094	0,067	0,407
9—25	1,600	0,024	0,677	0,263	0,080	0,048	0,391
25—73	2,672	0,019	0,868	0,847	0,278	0,075	0,515
73—100	1,738	0,018	0,468	0,522	0,160	0,052	0,278
180—250	0,464	0,021	0,173	0,069	0,020	0,009	0,112

Note: Comma represents decimal point.

(Table 3 continued)

Depth, cm	Solid residue	Alkalinity from HCO_3	Cl	SO_4	Ca	Mg	Na by difference
Primitive light-chestnut soil, coarse clay loam, solonchak-like, Profile 1230							
0—25	0,340	0,041	0,142	0,062	—	—	—
25—50	1,124	0,030	0,373	0,377	—	—	—
50—100	1,106	0,022	0,337	0,345	—	—	—
100—150	0,640	0,021	0,213	0,151	—	—	—
150—210	0,293	0,024	0,089	0,073	—	—	—
Primitive light-chestnut sandy loam, Hole 17							
50—60	0,180	0,029	0,074	0,020	0,012	0,005	0,045
100—120	0,370	0,029	0,087	0,104	0,032	0,016	0,050
180—200	0,562	0,022	0,175	0,094	0,045	0,024	0,069
250—270	0,492	0,033	0,142	0,140	0,005	0,020	0,128
300—320	0,100	0,024	0,016	0,031	0,018	0,006	0,002
350—370	0,230	0,028	0,031	0,047	0,028	0,003	0,015
400—420	0,200	0,030	0,054	0,047	0,016	0,004	0,043
450—470	0,109	0,029	0,021	0,016	0,014	0,006	0,004
500—520	0,198	0,032	0,054	0,055	0,015	0,004	0,048
550—570	1,670	0,035	0,403	0,536	0,068	0,040	0,377
600—620	0,962	0,038	0,347	0,133	0,024	0,025	0,228
650—670	3,134	0,035	0,684	1,131	0,324	0,096	0,444
740—750	2,230	0,045	0,508	0,888	0,276	0,078	0,306
Ground water, g/l							
510	48,360	0,390	23,684	5,374	0,924	2,328	12,618
Deeply cultivated, irrigated clay, Profile 1							
0—10	0,864	0,029	0,035	0,423	—	—	—
10—30	0,740	0,026	0,023	0,411	—	—	—
30—50	0,534	0,033	0,005	0,357	—	—	—
50—75	0,832	0,029	0,009	0,534	—	—	—
75—100	0,422	0,030	0,016	0,238	—	—	—
100—160	0,570	0,028	0,012	0,267	—	—	—
160—190	0,592	0,028	0,046	0,262	—	—	—
200—230	0,196	0,047	0,019	0,041	—	—	—

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[a] Made in the area of Profile 1230

Note: Comma represents decimal point.

tent of salts in the upper 1.5 m remained
ctically unchanged. Thus seasonal move-
its of salts affected only the upper 1.5 m.
erally, only chloride salts move. If we as-
ie that all the chloride is contained in sodium
oride, then the relative proportion of chlor-
; in the salts, leached from the upper 0.5 m,
nore than 60%.

Vith ample wetting, exceeding the water-
ding capacity of soil, which is usual under
existing conditions without systematic
gation, salts very often enter ground water
move together with the local ground-water
. These movements are most definite
ig constantly active channels in irrigated
iaries and rice fields.

The total width of the desalinized strip along channels of medium size does not exceed 100-200 m. If there are no irrigated areas in the vicinity, this strip is often bordered by solonchak-like soils and solonchaks containing 2%-3% of salts in the upper 0.5 m (Table 8, Profile 30).

The movement of salts takes place away from the channels, rice fields and estuaries according to the principle of the so-called "dry drainage." As may be seen from Table 8, already at a distance of 20 m from the boundary of the rice field there are solonchaks with a salt content of about 3% in the upper 0.5 m (Profile 15). Solonchaks are also as common around flooded lakes-estuaries (Profile 21).

The smallest microrelief forms are subject

Table 4

Salinized marine and alluvial deposits

Hole No.	Site	Depth, meters	Solid residue	Chloride	Chloride in % of solid residue
			in %		
939	200 m from the shore in the sea facing Lopukhovka Village	0,5	0,478	0,213	44
		1,0	0,702	0,319	46
	Same	1,5	0,886	0,336	38
	"	2,0	0,732	0,350	47
	"	2,5	0,658	0,319	48
	"	3,0	0,774	0,372	48
	"	3,5	0,166	0,088	50
	"	4,5	0,850	0,336	39
	"	5,0	0,562	0,266	48
1029	In the bed of the Old Terek facing Burunbay Village	1,0	0,072	0,007	10
		2,0	0,043	0,007	15
	Same	3,0	0,128	0,005	4
	"	4,0	0,091	0,005	6
	"	5,0	0,095	0,011	11
	"	6,0	0,068	0,007	10

Note: Comma represents decimal point.

Table 5

Mineralization of sea and river water

Point of observation	Data of sampling	Solid residue	HCO_3	Cl	SO_4	Ca	Mg	Na + K by difference
Sea, Lopukhovka Village	June 1955	9400	744	3156	1580	508	259	2010
			5	33	12	9	8	33
Terek River, Kargalinskoye Village	July 1954	275	132	58	12	47	9	14
			29	16	5	32	10	8

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[a] Numerator, mg per liter; denominator = % of the total meq

[b] Data from the Hydrological Yearbook for 1954 (Vol. 3, Leningrad, 1957)

Note: Comma represents decimal point.

Table 6

Area occupied by soils of varying salinization according to surveys in 1932 and 1954 in the area of the Old Terek irrigation system (1600 km^2), in %

Year of the survey	Gradation of soil salinization		
	Not salnz. and weakly salnz.	Moderately salinized	Solonchak and solonchak-like soils
1932. According to investigations by S. V. Zonn	29	32	39
1954. Soil surveys under the supervision of the author	27	31	42

Note: Comma represents decimal point.

Table 7

Content of easily soluble salts according to seasons in the profile of Tsvetkovskiy farm in Novoterechnoye Village, in %

Layer thickness, cm	November, 1953		April, 1954				Comments
	Solid residue	Chloride	Solid residue	Accretion	Chloride	Accretion	
0—50	1,24	0,37	0,83	—0,41	0,22	—0,15	Mean of 11 profiles
50—100	1,32	0,33	1,49	+0,17	0,38	+0,05	
00—150	2,03	0,23	2,30	+0,27	0,27	+0,04	
0—150	1,53	0,31	1,54	+0,01	0,29	—0,02	

Note: Comma represents decimal point.

Table 8

Average salinity of various soils according to solid residue, in %

Soil, land use	Profile No.	Layer thickness, m			
		0—0,5	0,5—1	1—1,5	0—1,5
Meadow solonchak-like, fallow 300 m from a rice field	25	1,69	1,49	2,88	2,00
Solonchak, 20 m from a rice field	15	3,01	2,56	—	—
Middle of the rice paddy after water drainage	16	0,67	0,67	—	—
Solonchak 100 m from an irrigated field (lake-estuary)	21	3,00	2,28	—	—
Meadow, weakly solonchakized soil, abandoned	24	0,22	0,56	0,42	0,40
Irrigated field, microelevation	121	1,36	0,84	0,62	0,94
Irrigated field, level area 130 m from Profile 121	122	0,16	0,16	0,14	0,15
Solonchak, 60 m from a channel	30	2,41	1,91	0,69	1,67

Note: Comma represents decimal point.

omparatively high salinization. For instance, % of salts accumulated in an almost invisi- microelevation in the middle of an irrigated d, while next to it the soils were not salin- l (Table 8, Profiles 121 and 122).

Conclusions

. The data obtained confirm that saliniza- takes place in the Terek delta. The rate alinization is approximately equal to the mulation of salts in relation to the salt con- s in the upper 2 m of soil.

. Most intense salinization takes place in s under the immediate influence of the Freshly-deposited alluvium is not salin- . As it "ages" it becomes more salinized.

. To obtain consistently high crop yields and ease the future coefficient of land use in the Terek delta, drastic meliorative measures are needed, such as drainage and leaching.

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BIBLIOGRAPHY

1. BANASEVICH, N. I., S. V. ZONN, and others. 1934. Processes of soil salinization and desalinization in relation to ground waters, their salinization and the influence of the Caspian Sea. Leningrad-Makhachkala.

2. KOVDA, V. A. 1946-1947. Origin and regime of saline soils. Vol. 1-2. Moscow.

3. KOVDA, V. A., V. V. YEGOROV, A. T. MOROZOV, and YU. P. LEBEDEV. 1954. Principles of the process of salt accumulation in the deserts of the Aral-Caspian

lowland. Trudy Pochvennogo instituta im. V. V. Dokuchayeva Akad. Nauk SSSR. Vol. 44.

4. SOKOLOVSKIY, S. P. 1955. Soil melioration conditions in the area of the Old Terek irrigation system (for the reconstruction project, Book No. 15). Funds of the Branch of the Southern State Institute for the Planning of the Water Economy and Meliorative Construction. Manuscript. Pyatigorsk.

METHODS

UALITATIVE ASSESSMENTS OF LANDS ON THE BASIS OF ATURAL CONDITIONS AS APPLICABLE TO HORTICULTURE

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In determining the suitability of land to rticulture, the soil scientist must take into count soils and parent materials and, in the esence of two-layered profiles, the under- ing geological material, i.e., the entire ickness of soil and soil material to a depth to ich the main mass of the roots of fruit- and rry-plants penetrates. The quality of the soil determined in relation to a given fruit- or rry-plant, or a group of plants, which have milar requirements for their life activity om the complex of natural conditions, includ- g soils and soil materials. Thus, the deter- ination of the quality of soils must be closely lated to the biological study of the character- tics of fruit- and berry-plants.

The assessment of soils (their inventory) cludes two interrelated elements: quantity, expressed in unit area (ha), and quality, in is case the characteristics of the natural pro- ctive capacity of soils.

As a basis for the qualitative characteristics land for horticulture we take the complex ıdy of the following natural factors:

a) the biological requirements of horticul- ral plants under definite external conditions growth, including soil and soil material, in e given area; b) geographical location and omorphological conditions of the area; c) imatic and microclimatic conditions of plant owth; d) natural vegetation and soil of a given ea; e) the most important morphogenetic and ysicochemical indices of the typical soils of e area investigated; and f) the most important orphogenetic indices of the surface and sub- rface portions of fruit- and berry-plants, and so associated wild trees, shrubs and semi- rubs.

The most important qualitative indices and licators of the complexity of natural condi- ns, which must be considered by the soil ientist, are only those which are stable. pidly changing indices, especially those which e due to current agricultural practices, must studied and assessed by agronomists, econo- sts and others who take part in the qualitative sessment of land.

It must be noted that stable natural indices ve a different importance depending on the tural conditions (1). For instance, one and the same soil index, such as texture, has a different importance for the life activity of the root system of plants in a humid climate than it does under conditions of deficient moisture and a warmer climate. For instance, coarse clay loam in the zone of sod-podzolic soils of the European USSR is the most suitable media for the development of apple tree roots, while in the zone of leached and thick chernozem it is less favorable to apple tree than is fine clay loam.

In the Luga district of the Leningrad Region the optimum texture for apple orchards is that of fine sandy loam because the climate here is more humid than in the Moscow Region, for instance.

Under a given complex of natural conditions individual stable indices may sometimes be dominant, even decisive in relation to all others, or on the contrary may be of little importance for the qualitative evaluation of an area. Microclimate may serve as an example. Late spring frosts in the flood-plain of the Moskva River last 2-4 weeks longer than in elevated and watershed areas and embrace the period of bloom of strawberry. In spite of the fact that flood-plain soils are richer and more favorable as far as moisture is concerned than the sod-podzolic soils of watersheds, they are not favorable for the planting of strawberry because of the interfering late spring frosts.

Slopes exposure, which affects the microclimate of the air layer near the ground, assumes in the complex of natural conditions a very important role in the distribution of such plantings as apple trees, black currant and strawberry for which southeastern and eastern slopes in the central fruit-growing zone are less favorable than for cherry or gooseberry. More to the southeast toward the Voronezh, Saratov, and Stalingrad Regions, southeastern and eastern slopes become not only unfavorable, but unsuitable for the foregoing plants, in spite of otherwise favorable natural conditions. Cherry and gooseberry may successfully be grown on such slopes.

The importance of the parent material is illustrated by the following example. We have a good site for the growing of apples and pears, such as a southwestern gentle slope of medium elevation and a weakly podzolized clay loam sod soil, but the parent material at a depth of 50 cm is represented by an original clay loam moraine. Such parent material is distinguished by poor air and water permeability, and great density and does not allow the development of deep root systems of pomaceous species. In this case the parent material plays the decisive role in the qualitative evaluation of the suitability of the area for the growing of apples and pears. Such soil conditions are fully suitable for the growth of cherry, raspberry and strawberry.

A similar importance is assumed by gleyization at a depth of 1.5 m. In spite of the favorable soil texture, a sufficient amount of nutrients, a good location as far as relief is concerned, etc., gleyization makes the given area unsuitable for a pomaceous orchard. At the same time the gleyization of soil from a depth of 1.5 m under otherwise similar conditions would have no negative effect on the growing of plums, black currant and raspberry.

The heat regime of the soils at a given depth is also sometimes a determining factor in the qualitative characterization of an area. For instance, a site may be very favorable for the growing of a pomaceous orchard, the relief and soil may also be suitable without any gleying, but the temperature at a depth of 1.0-1.5 m sharply decreases by 2°-4°C as a result of the lateral movement at this depth of cold ground water having a constant temperature of 8°-10°C in summer. Such cooling of the soil leads to the depressed development of fruit-bearing plants, to the chlorosis of leaves and the early dying of trees.

Examples of this kind are numerous. They confirm the necessity of giving decisive importance in many cases to individual natural factors when evaluating the quality of land. However, the final result of a qualitative evaluation of land and the selection of the method of utilizing it must be based only on the combination of all the important natural indices.

Taking into account the characteristics of a "garden," under which we understand an area occupied by artificial plantings of fruits, berries, nuts, ornamental-flowers and others (2), we distinguish two types of gardens: commercial orchards and small gardens.

The evaluation of the same area would differ depending on its intended use, for instance: areas which are found suitable for house gardens may be unsuitable for a large orchard as a result of the complexity of soils, the variety of relief elements, the impossibility of mechanically cultivating the area, etc.

The qualitative evaluation of horticultural land is based on the following:

a) Horticultural lands, being very valuable agricultural lands, require more detailed and comprehensive study of their properities and since the area under horticulture is generally very small as compared to the area used for agriculture, the selection of a plot for horticulture requires special investigation and substantiation (3).

b) Perennial plantings predominate in orchards, so that the use of the land under one and the same plant sometimes lasts 60-100 and more years, which leads to a substantial change in soil conditions.

c) The establishment of an orchard is always associated with great expenditures of money and work, so that an incorrect evaluation of the land or an insufficient substantiation would lead to great losses.

d) The qualitative suitability of an area must be evaluated keeping in mind the time it takes for the plants to reach their economically profitable age, that is, 80-100 years for pomaceous plants, 25-40 years for stone fruits, 15-20 years for berry bushes and 5-7 years for strawberries.

e) The qualitative evaluation of soils for orchards requires investigations to greater depths and in greater detail than that for field crops, for instance, because of the nature of the development of the root system of fruits and berries. Soil must be studied to a depth of up to 2-3 m for pomaceous plants, such as apples and pears; 2-2.5 m for stone fruits, such as plums, apricots and peaches; 1.5 m for cherry; up to 1.5 m for gooseberry and black currant; and up to 1 m for raspberry and strawberry.

On the basis of long years of investigation we are deeply convinced that a knowledge of the suitability of land is gained first of all from the nature of the development of the root systems of horticultural plants and, in the absence of orchards, from the nature of the development of the root systems of wild and cultivated plants which are naturally associated in orchards in a given natural region.

In the opinion of Professor Shitt (8, 9), Lolesnikov (6, 7), Zhuchkov (5), and others, the root systems of fruit- and berry-plants are "self-recording" in that they reflect in the nature of their development and propagation their life conditions in the underground medium. Observations on the root distribution of these plants along genetic soil horizons allow characterization of the natural qualities of the soils in relation to a given fruit- or berry-plant or a biologically similar group of plants which have the same requirements of the soil medium and the entire complex of natural conditions as a whole.

The tops of fruit- and berry-plants, which is in direct relation with the root system, also serves as a good indicator of the productivity and quality of soil. In our opinion, the yield of orchards is a more remote criterion for the evaluation of the natural conditions of soils. This is more of a criterion in the agronomical and economical evaluation of lands and is related to the agricultural practices and economical cultivation of plants. The evaluation of orchards by agronomists and economists according to yield may not correspond to the evaluation on the basis of natural conditions. If they do correspond it indicates that natural conditions were properly utilized in agricultural production. If, however, the natural and agricultural-economical evaluations differ sharply it indicates either that the natural conditions were improperly used in agriculture, or

at there is a discrepancy between work and
oney expenditures for the creation of a good
eld and the productivity of the land.

The final decision on the use of land in
griculture must be made by agronomists,
onomists and land users; soil scientists give
ly the initial material on the quality of a land
ea and resultant recommendations on its
tional use.

In relation to what was said previously, we
ust indicate certain characteristics of the
ethodology of the investigating orchards and
w land areas for orchards.

The determination of the suitability of an
ea for horticulture must not be limited to the
vestigation of the area only; the given site
ust be related to hypsometric levels and the
rms and nature of the relief in the general
ndscape. This will allow evaluation of the
riations in the microclimate of the given
chard area in relation to the surrounding
ea.

In selecting the site and soil for an orchard
is necessary to take into account the state of
uit- and berry-plants during their various
ges, such as youth, the bearing period and
ing, and also their state at one and the same
e, such as intense, medium and depressed
evelopment, depending on soil and other con-
tions.

If orchards are present in the given region,
en though they are outside the selected area,
ey are the first to be investigated in the fore-
oing directions, such as for the age and de-
lopment of plants in typical geomorphological
d soil conditions. By comparing the complex
natural conditions in these orchard areas
ith those of the selected areas, the quality and
itability of the latter for orchards are deter-
ined.

If there are no orchards in the given natural
gion, investigations are made of the state of
ild-growing plants which are associated with
uit- and berry-plants, such as oaks, bass-
oods, mountain ash, filberts, birches, pines,
asses and legumes, wild raspberry, currant,
rawberry, dog rose, etc.

Both the state of the top and roots of fruit-,
rry-, and wild-plants are studied and the fol-
wing indices are noted: 1) for the upper
rtion of woody plants: age, circumference of
e stem at a height of 50 cm above the root
llar, the height of the stem from the soil
rface to the crown, the depth of the crown,
e total height of the tree, the diameter of the
own from north to south and from west to
st, the nature of leaves, damage and dying off
branches, suckers in the crown, etc.; for
e roots: a) the distribution of roots down-
ard along genetic horizons, dividing them into
ain roots and secondary (fibrous roots) and
alifying them in the following manner: very
any roots, many, medium number, few, and
ngle; b) lateral distribution of roots in indi-
dual genetic horizons, with the same sub-
visions for the first meter from the stem, the
cond meter, etc. In both cases it is import-
t to note damaged, rotting, or dying off roots.

This work is done by the soil scientist in cooperation with an agronomist, horticulturist, or an experienced kolkhoz gardener. In the selection of horticultural or wild plants for study, account is taken of the geomorphological situation, soil and soil material conditions and the biological state of the plants. The plant tops in particular apple trees, must be characterized according to Shitt's (8) nine "age periods":

The first period — 5-8 years before the plant gives fruit; the second; from 5-10 years, when the plant begins to bear; the third, from 10-20 years, when it bears regularly; the fourth, approximately to the age of 40 years, with maximum yield for 12 consecutive years; the fifth, of 10 years, when small branches bear fruit and die off; the sixth, when the life activity of the tree slows down, small main and secondary fruit-bearing branches die off, the growth of "suckers" is renewed primarily in the peripheral portions of the crown when the tree is older than 50 years; the seventh, when main branches bear fruit and die off and "suckers" appear in the inner portions of the crown at an age of 60 years; the eighth, when the tree does not bear any more and large main branches die off after the age of 60-80 years; and the ninth, when the tree retains some signs of life, its last period of life.

"Age periods" in the life of a fruit tree begin, as we have seen, at various times, depending on various physiographic and climatic conditions. For instance, in the lower reaches of the Kuban' River in Slavyanskaya Village, an apple tree reaches its maximum height of 7 m, its maximum stem circumference of up to 100 cm and more, and its maximum bearing period (fourth period) at the age from 18-23 years, while it begins to die off and stops bearing (eighth period) at the age of about 40. In the Moscow Region, an apple tree reaches its maximum development and maximum bearing period at the age of 30-40 years (fourth period) and begins to die off and stops bearing at the age of about 80 years. In both cases the complex of natural conditions is favorable, the difference here being in the geographical conditions.

Within one natural region the life span of a fruit tree and its age periods may vary sharply depending on the presence of individual unfavorable geomorphological, soil and other factors.

The foregoing shows how numerous and varied are natural indices which characterize the quality of horticultural land.

As a result of the generalizations made previously, tables are compiled for the evaluation of horticultural land according to natural conditions as related to the most common orchard plantations, such as apples and pears, cherry and gooseberry, plums and raspberry, strawberry, and black currant. The evaluation tables, compiled on the basis of investigations, must contain determinations of all components of the complex of natural conditions: the genetic group and subgroup of soil; the geographical coordinates of the site; its location in the landscape; relief and exposure; parent material; soil texture; soil moisture conditions; water level in the profile; and the microclimate of the air layer near the ground. The site quality of the horticultural area is determined from the combination of all these determinations. We divide horticultural lands into the following 4 classes:

Class 1 — ensures optimum life activity for fruit- and berry-plants up to their economically productive age, intense development and highest yield.

Class 2 — ensures the same life span for fruit- and berry-plants, but with a lesser development and yield under the same conditions.

Class 3 — does not ensure full life span, intense development and high yields, leads to the early dying of horticultural plants.

Class 4 — is unsuitable for fruit and berry plants; however, after drastic melioration the land may partly be used for certain horticultural plants.

Note. If every one of the previously mentioned natural indices is optimum for the life of a given fruit and berry plant, the evaluation of the given area would be the highest, i. e., Class 1.

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BIBLIOGRAPHY

1. GRUZDEV, G.I. 1937. Soil conditions of fruit plantations. Handbook on fruit growing for agronomists. Sel'khozgiz.
2. GRUZDEV, G.I. 1941. The problem of the nomenclature and classification of lands. Pochvovedeniye, No. 9.
3. GRUZDEV, G.I. 1956. Selection of the site and soil for a garden. Sel'khozgiz.
4. GRUZDEV, G.I. 1942. Field description of soil. Glavnoye upravleniye zemleustroystva SSSR. Omsk.
5. ZHUCHKOV, N.G. 1940. Individual fruit growing. Sel'khozgiz.
6. KOLESNIKOV, V.A. 1924. Root system of fruit trees. Nauchno-agronomicheskiy zhurnal. No. 3.
7. KOLESNIKOV, V.A. 1958. Root system of fruit- and berry-plants. Vestnik sel'skokhozyaystvennoy nauki. No. 4.
8. SHITT, P.G. 1930. Method and program of biological investigations of fruit tree plantings. Sadvintrest RSFSR.
9. SHITT, P.G. 1940. Fruit growing. Sel'khozgiz.

ROBLEMS OF THE TRANSITION OF SOUTHERN CHERNOZEMS O DARK-CHESTNUT SOILS OF THE CENTRAL PORTION OF THE RIMEAN STEPPE

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The central part of the Crimean steppe is imarily represented by chernozems, however, ere are transitional soils between chernozem d dark-chestnut soils. We did not determine e limit of this transitional subgroup, but in the rasnogvardeysk region it is widely distributed der zonal conditions.

The literature on the soils of the Crimean eppe is very contradictory. Already Murchin- n, Tyuo, Radde, Romanovskiy and certain dastral commissions had noted the distribution chernozem in Crimea (quoted from Dokucha- v, 5). Ruprekht (12), who studied cherno- m and compiled a special map of chernozem stribution in Russia in 1866, did not show the rimean chernozem on it. The existence of is soil was denied by I. I. Vil'son and V. I. naslavskiy.

I. F. Levakovskiy (9) noted that "...at a dis- nce of about 100 verst to the north of Simfero- l' chernozem begins to disappear, while lonchak, consisting of brown clay which is the ual subsoil of chernozem, becomes more prev- ent toward Lake Sivash..., however, there is area near the Chongara bridge with fairly ick chernozem."

As a result of his trip to Crimea (1879), V. V. kuchayev for the first time substantiated the de distribution of chernozem in the central rt of the Crimean steppe. He also determined it toward the north of Simferopol' chernozem comes more and more shallow, while in the cinity of the shore of Lake Sivash chernozem adually disappears.

"Soon after Simferopol' on the way to the ongara bridge at Lake Sivash the steppe be- me more and more even and uniform, the getation became lower and poorer until it adually and unnoticeably merged with the mud- shore of the Gniloye Sea. The Simferopol' ernozem also disappeared gradually." Doku- ayev studied the soils near the Kuman- mel'chi railroad station (Krasnogvardeysk strict). Dokuchayev wrote that chernozem s "of a chocolate-gray color and 1 foot thick cm)," and contained more than 3% humus. tipov-Karatayev and Prasolov (1) wrote:

"As far as the central part of the Crimean ppe is concerned, we must apparently also tinguish between the same members of the series: solonchaks, solonetzes, solonetzic southern chernozem (equivalent to the chestnut chernozem of Ukrainian soil scientists) and southern chernozem." Sokolov (13) drew attention primarily to dark-chestnut soils in the Crimean steppe, he classified chernozem as belonging to the first series of the vertical soil belt of Crimea. Klepinin (8) distinguishes a larger number of soil groups, such as southern chernozem, carbonate, dark and light-chestnut soils, etc. Dzens-Litovskaya (4) is of the opinion that "Zonal soils are peculiar to the watersheds occupied by clay loam in the Crimean steppe, and combine both the characteristics of chernozem and dark-chestnut soils." Antonova (2) made a detailed study in 1927 of the soil of the experimental station in the Crimean steppe and established that southern chernozems are found in valleys. Gusev (3) showed that the soils of the experimental station are primarily represented by southern chernozems which are weakly humified and develop on Quaternary yellow-brown loess-like coarse clays. Popova (10) also found southern chernozems in the area of the experimental station, however, she points out that "they should not be identified with chernozems occupying the more moist southern part of the Crimean valley, because the latter clearly reflect in their appearance and properties all the main features of the chernozem formation process." The relief of this area is flat. Erosion is weakly developed. The parent material consists of Quaternary loess-like deposits which are rich in carbonates and gypsum. They are yellow-brown and brownish-yellow in color, and brownish-yellow with a reddish tinge from a depth of 4 m down. Texturally they are silty-clay coarse clays. Ground water at the present time is very deep and has no influence on the process of soil formation. The morphological structure of these transitional soils may be seen from the description of Profile 2.

Profile 2. Made on a flat watershed 150 m to the north of the road leading from Krasnogvardeysk to Klepinino across from the "Magarach" vineyards.

A 0-18 cm. Gray with a clearly defined light-brownish tinge, dry, only slightly compacted, fine clay loam. Very powdery and sometimes cloddy and blocky-cloddy. Becomes covered with a compact surface crust after rain. Riddled with roots. Has vertical cracks (4-12 cm long). Does not effervesce from HCl. The transition to the A horizon is clear in color, structure and compactness.

A 18-36 cm. Dark-gray with a brownish tinge, dry, more compacted, fine clay loam of a blocky-granular structure, riddled with roots. There are vertical fissures (2-4 cm long). Does not effervesce from HCl. The transition to the next horizon is clear in color, structure and compactness.

B_c 36-52 cm. Yellow-brown, damp, compacted (looser than the A horizon), heavy clay loam-like of a coarse and fine blocky structure, contains larger roots, coprolite, worm holes and humus tongues. There are vertical fissures (0.2-0.5 cm long). Effervesces from HCl. The transition to the C_c horizon is noticeable by the appearance of white specks.

C_c 52-100 cm. Light yellow-brown, damp, very compact fine clay loam, breaks up into blocks and lumps 3-5 cm in diameter. There are humus tongues in the upper part of the horizon. A large number of clearly-defined white specks appear at a depth of 55 cm, reaching a maximum between 65-85 cm. There are no white specks below 101 cm. Effervesces from HCl.

C_c^1 100-141 cm. Brownish-yellow, light, compacted, fine clay loam, can be pried loose in lumps. There are films (from brown to dark-brown) along the boundaries of structural units. Contains holes from large roots and worm holes with coprolite. Effervesces from HCl.

C_{cgyp}^2 141-244 cm. Brownish-yellow, damp, compacted, heavy clay loam. The structure is indefinite; there are films along the boundaries of structural aggregates (of a brown or black-brown color). There are accumulations of gypsum in the form of interlayers and pockets. The gypsum content is higher in the upper portion of the horizon and decreases with depth. Effervesces from HCl.

C_{cgyp}^3 244-307 cm. Brownish-yellow, damp, compacted, fine clay loam of an indefinite structure; carbonates appear again but in a lesser amount than in the horizon containing white specks. There are gypsum nodules scattered throughout the horizon. Effervesces from HCl.

C_{cgyp}^4 307-347 cm. Brownish-grayish-yellow with a reddish tinge, damp, compact, fine clay loam, has occasional gypsum accumulations in the form of nodules; krotovinas.

C_{cgyp}^5 347-405 cm. More reddish than C^4, damp, compact, fine clay loam, has occasional accumulations of carbonates in addition to gypsum. Effervesces from HCl.

As may be seen from the foregoing morphological description, and from the study of other profiles and semi-trenches made under similar geomorphological conditions, these soils are distinguished by the following morphogenetic indices (Table 1).

The color of the plowed layer (gray with a light-brownish tinge) is lighter than that of the layer underlying it (gray with a brownish tinge). The thickness of the uniformly colored humus horizon is 35-40 cm. The thickness of the A + B horizon is 50-60 cm. The humus and transitional horizons are full of roots. The structure of the plowed layer is blocky-lumpy, powdery and blocky-granular in the A horizon.

There are very many cracks from the surface to a depth of 50-60 cm in the humus and transitional horizons.[1] The width of the cracks reaches 4-8-12 cm at the surface, becoming finer with depth.

In the B_c and C_c horizons there are worm holes with coprolite, while the krotovinas in the C_{cgyp}^4 horizon are filled with black soil. Effervescence from HCl begins below the uniform humus horizon. From a depth of 50-60 cm down there is a horizon with an accumulation of white specks. The maximum accumulation of carbonate salts is found in the layer from 65-85 cm deep. Gypsum appears at a depth of 140 cm and is concentrated in the layer from 140-170 cm deep. There is again an accumulation of carbonic salts in the C^1_{cgyp} horizon and of carbonates and gypsum in the C_{cgyp}^5 horizon. Gusev (3) notes that there are several horizons in the parent material where there is a concentration of water-soluble salts, primarily sulfates, which probably indicate a higher level of ground water. It may be assumed that at one time these chernozems underwent the meadow stage of soil

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[1] We made our observations in August 1958; there was no rain from May to August.

Table 1

Morphogenetic indices of southern chernozems changing into dark-chestnut soils

№		Thickness, cm		Depth, cm		
Profile	Semi-trench	Humus horizon	A+B	Location of white specks	Effervescence from HCl	Location of gypsum
2	—	36	52	52	40	141
3	—	37	55	55	42	144
—	1	39	58	58	45	—
—	2	38	50	50	35	—

Table 2

Temperature fluctuations in the winter of 1927-1928
(according to B. I. Dukarovich, 6)

Date of observation	Temperature, °C	Date of observation	Temperature, °C
Dec. 12	— 9,3	Feb. 8	—21,6
Dec. 14	+10,2	Feb. 12	+10,6
Dec. 15	— 3,2	Feb. 16	— 6,6
Dec. 17	+13,0	Feb. 18	+ 7,0

Note: Comma represents decimal point.

rmation. In their lower horizons there are lms along the structural faces of the aggregates.

For the sake of comparison let us give a escription of dark-chestnut soils and examine the same time all the analytical material on outhern chernozem and dark-chestnut soils.

Profile 6. Made in the Crimean steppe in the area of Dzhankoy in a watershed occupied by plowed land and parent material is loess-like clay.

Table 3

Daily temperature fluctuations
(according to Dukarevich)

Date of observation	Temperature, °C
Feb. 3, 1946	+11,9 —8,2
Feb. 4, 1946	+ 7,7 —3,4

Note: Comma represents decimal point.

A_p 0-25 cm. Chestnut, dry, compact, silty-clay of a lumpy-nutty-silty structure with a tendency toward platiness, contains roots and vertical cracks; does not effervesce from HCl. The transition to the next horizon is clear in color and structure.

A_1 25-45 cm. Grayish-dark-brown, damp, compact, silty-clay of a nutty-blocky-granular structure; there are films along the faces of structural aggregates and roots. Does not effervesce from HCl. The transition to the next horizon is abrupt in color and consistency.

B_c 45-60 cm. Yellowish-brown, damp, compact, silty-clay of a blocky-nutty structure; in the upper part of the humus horizon there are humus intrusions in the form of pockets and tongues; there are white specks (in the lower part of the horizon) and worm holes with coprolite. Effervesces from HCl. The transition is clear.

C_c 60-110 cm. Yellowish-brown, dry,

Table 4

Analysis of water extracts of southern chernozem changing into dark-chestnut soil (Profile 2)

Depth, cm	Dry residue, %	Total alkalinity of HCO_3	Cl^-	CO_4^{--}	Ca^{++}	Mg^{++}	Na by difference	Total salts meq
115—125	0,120	$\frac{0,070^{a}}{1,15}$	none	$\frac{0,019}{0,39}$	$\frac{0,005}{0,23}$	none	$\frac{0,030}{0,81}$	0,124
141—151	1,458	$\frac{0,025}{0,41}$	»	$\frac{0,973}{20,27}$	$\frac{0,263}{13,15}$	$\frac{0,020}{1,66}$	$\frac{0,135}{5,87}$	1,416
210—220	0,495	$\frac{0,019}{0,31}$	$\frac{0,099}{0,25}$	$\frac{1,057}{22,02}$	$\frac{0,241}{12,05}$	$\frac{0,087}{7,25}$	$\frac{0,075}{3,28}$	1,488
265—275	0,300	$\frac{0,038}{0,62}$	$\frac{0,019}{0,53}$	$\frac{0,145}{3,02}$	$\frac{0,009}{0,45}$	$\frac{0,006}{0,45}$	$\frac{0,075}{3,27}$	0,292
320—330	0,484	$\frac{0,032}{0,52}$	$\frac{0,039}{1,09}$	$\frac{0,268}{5,58}$	$\frac{0,028}{1,40}$	$\frac{0,017}{1,41}$	$\frac{0,101}{4,38}$	0,485

[a] In the numerator—meq; in the denominator—% of dry soil.
Note: Comma represents decimal point.

compact, silty-coarse clay loam of a nutty structure; there are krotovinas, roots, worm holes with coprolite and a large number of white specks (varigated in color). Effervesces from HCl.

C^1_c 110-150 cm. Yellow-brown with a reddish tinge, dry, very compact, silty-clay; there are krotovinas 5-16 cm in diameter. Effervesces from HCl.

C^2_{cgyp} 150-205 cm. Light-yellow, damp, compact, coarse clay loam; contains gypsum in the form of veins and pockets; animal burrows. Effervesces from HCl.

C^3_{cgyp} 205-278 cm. Light-yellow with a reddish tinge, damp, compact, silty-clay; gypsum is evenly distributed; there are gray films along the faces of structural aggregates. Effervesces from HCl.

C^4_{cgyp} 278-348 cm. Differs from the preceding horizon by a larger amount of black films and gypsum in the form of nodules.

C^5_{cgyp} 348-400 cm. Reddish-yellow, black films, accumulation of carbonates at a depth of 380-400 cm.

From the foregoing morphological description of Profile 6 and from other profiles and semi-trenches it follows that the humus horizon is 37-45 cm thick. Effervescence begins at a depth from 38-45 cm; white specks are found at a depth of 40-55 cm.

In the B_c horizon (45-60 cm) there are clearly defined intrusions in the form of pockets and tongues. The amount of humus in the plowed horizon is 2.5% and slowly decreases with depth. In the dry year of 1958 there were vertical cracks 5 to 8-12 cm wide in the humus horizon. The structure is lumpy-nutty with a tendency toward platiness in the A_p horizon and becomes nutty-blocky-granular in the A_1 horizon. The soil effervesces primarily below the uniformly colored horizon. The boundary of effervescence is uneven. The main mass of roots is contained in the humus horizon. There are films along the faces of structural aggregates in the A_1 horizon. The transition from the humus horizon to the illuvial horizon is clear in structure and color.

The carbonate horizon begins with abundant and clearly-defined white specks. Humus penetrates into it in the form of tongues and pockets. Coprolite is found in the B_c and C_c horizons; there are many worm holes. Krotovinas in the C_c, C^1_c and C^2_c horizons are 5-16 cm in diameter. At a depth of 150 cm there are accumulations of gypsum in the form of veins and nodules.

Gray and black films are found in the C^3_{cgyp}, C^4_{cgyp} and C^5_{cgyp} horizons.

The parent material is found below a depth of 400 cm and consists of loess-like clay of a reddish-yellow color without visible salt inclusions; it is compact, damp and not very porous.

Southern chernozems are characterized by a low humus content (Table 8). The shallowness of the humus and the transitional horizons, the deposits of carbonates and gypsum near the surfaces are explainable by the bioclimatic conditions of the central part of the Crimean steppe. The climate of the area under study is clearly continental (Tables 2 and 3). Penyugalov (11) points out that the climate is under the moderating influence of the Black Sea; the influence of

Table 5

Analysis of water extracts of dark-chestnut soil (Profile 6)

Depth, cm	Dry residue, %	Total alkalinity of HCO_3	Cl^-	SO_4^{--}	Ca^{++}	Mg^{++}	Na^+ by difference	Total salts, meq
120—130	0,192	$\frac{0,045^{a}}{0,74}$	$\frac{0,036}{0,01}$	$\frac{0,049}{1,02}$	$\frac{0,007}{0,34}$	$\frac{0,001}{0,11}$	$\frac{0,053}{2,32}$	0,191
170—180	1,581	$\frac{0,019}{0,31}$	$\frac{0,082}{2,31}$	$\frac{0,018}{21,21}$	$\frac{0,270}{13,50}$	$\frac{0,063}{5,25}$	$\frac{0,117}{5,08}$	1,569
235—245	1,842	$\frac{0,070}{0,33}$	$\frac{0,119}{3,35}$	$\frac{0,165}{24,29}$	$\frac{0,245}{12,25}$	$\frac{0,143}{8,58}$	$\frac{0,164}{7,14}$	1,816
300—310	1,778	$\frac{0,026}{0,42}$	$\frac{0,070}{1,97}$	$\frac{1,181}{24,60}$	$\frac{0,236}{11,80}$	$\frac{0,105}{8,75}$	$\frac{0,148}{6,44}$	1,766
330—340	1,540	$\frac{0,019}{0,31}$	$\frac{0,108}{3,04}$	$\frac{0,950}{19,79}$	$\frac{0,174}{8,70}$	$\frac{0,092}{7,66}$	$\frac{0,156}{6,78}$	1,499
390—400	0,704	$\frac{0,033}{0,54}$	$\frac{0,108}{3,04}$	$\frac{0,350}{7,29}$	$\frac{0,037}{1,85}$	$\frac{0,043}{3,58}$	$\frac{0,125}{5,44}$	0,696

[a] In the numerator—meq; in the denominator—% of dry soil.
Note: Comma represents decimal point.

he Sea of Azov is insignificant. At the same ime, the central part of the Crimean steppe is nder the strong influence of the southern teppe region of the Ukraine with its considerably nore sharply developed continental climate.

According to data from the Meteorological Iandbook of the USSR, the maximum air temperture of 40.7°C was recorded in 1925 and the ninimum was -33.1°C. According to mean ong-period data, annual precipitation amounts o 383 mm, including an average of 290 mm uring the growing period (the maximum is 315 nm and the minimum, 92 mm). Dry winds occur every year and last about 11 days (6) in ugust. Under such conditions vegetation is ery scant and gives little plant material for uilding up humus.

Under the conditions of the Crimean steppe, rganic matter decomposes rapidly. Dzens-itovskaya (4) writes: "...as a result of the lmost complete absence or short duration l-10 days) and shallow freezing of Crimean teppe soils, they always remain active, and recipitation, even though it is scant, has the ossibility to act on the soil for a long period f time." This is why the exchange of subtances between the soil and vegetation, the enichment of soil solutions with carbon dioxide nd the migration of carbonates are more inense here than in typical dark-chestnut soils of ne southeastern part of the European USSR, here, as a result of the cold climate, soils reeze to a depth of 1 m and remain frozen for period of 4-5 months.

With warm autumns and springs and comaratively warm winters, the major part of lant residues decomposes under normal soil noisture conditions, so that little humus acumulates. The low humus content in the plowed iyer is determined by both improper agriculural methods used for centuries, which led to ne decomposition of organic matter, and the ecrease in the amount of humus.

The fact that these transitional soils are poorly leached (comparatively high content of carbonates and gypsum near the surface) is the result of the non-leaching type of regime which predominates under conditions of the Crimean steppe. The conditions of the formation of dark-chestnut soils are characterized by even greater continentality and a lesser amount of precipitation.

Let us examine certain chemical and physical properties of southern chernozems, changing into dark-chestnut soils.

The adsorption capacity of the humus and the transitional horizons is 37-29 meq. It reaches a maximum in the A horizon and decreases considerably downward along the profile (Table 8).

Water-soluble salts (Profile 2) are contained in an insignificant amount to a depth of 141 cm. Below this depth their amount increases. Sulfates predominate among soluble salts. Normal carbonates are lacking in the entire profile as in the dark-chestnut soil (Table 4).

Dark-chestnut soils are similar to southern chernozems changing into dark-chestnut soil in as far as their type of salinization is concerned. However, the amount of salts in dark-chestnut soils is higher and increases with depth (Table 5).

Texturally (Table 6), southern chernozems are silty-clay soils. The total amount of particles <0.01 mm in diameter, together with pretreatment losses, is more than 60% in all horizons. The clay content varies from 19.2%-38.6%. The high content of clay in the humus horizon is associated with the specific biological exchange of substances in the central part of the Crimean steppe. Root residues are distributed more evenly in the soil here and when they decompose organo-mineral colloids accumulate. There is a weak differentiation in particle-size composition along the profile. A variation in the amount of particles <0.01 and <0.001 mm

Table 6

Particle-size analyses of southern chernozems, changing into dark-chestnut soils, % (according to Kachinskiy). Profile 2

Depth, cm	Hygroscopic moisture, %	Loss during pretreatment, %	Particle diameter, mm						Total
			1–0,25	0,25—0,05	0,05—0,01	0,01—0,005	0,005–0,001	<0,001	<0,01 мм
0—18	6,70	3,0	0,2	6,2	26,9	8,8	19,1	35,8	63,7
22—32	8,90	0,3	0,3	4,8	28,5	11,7	15,8	38,6	61,1
40—50	4,95	15,6	0,1	15,8	20,3	8,2	11,5	28,5	48,2
70—80	5,60	16,3	0,2	18,2	23,0	8,2	11,5	22,6	42,3
115—125	5,70	13,3	0,1	13,7	27,0	7,9	10,9	27,1	46,7
141—151	5,14	17,4	0,1	16,4	25,1	8,1	10,0	22,9	41,0
210—220	4,50	22,3	0,3	24,4	18,1	8,4	7,3	19,2	34,9
265—275	5,40	15,1	0,4	16,5	25,4	8,7	9,3	24,6	41,6
320—330	6,30	16,4	0,1	16,6	22,0	8,3	9,4	27,2	45,9
380—390	6,28	16,0	0,2	15,1	20,4	7,9	9,8	29,3	47,0

Note: Comma represents decimal point.

Table 7

Particle-size analyses of dark-chestnut soils, %(according to Kachinskiy). Profile 6.

Depth, cm	Hygroscopic moisture, %	Loss during pretreatment, %	Particle diameter, mm						Total
			1—0,25	0,25—0,05	0,05—0,01	0,01—0,005	0,005—0,001	<0,001	<0,01 мм
0—25	5,90	2,0	0,7	3,9	34,9	11,0	14,2	33,3	58,5
30—40	9,31	0,6	0,0	2,6	37,2	8,0	16,0	35,6	59,6
45—60	5,20	16,9	0,0	19,1	26,5	8,3	9,4	19,8	37,5
80—20	4,50	28,2	0,0	25,5	14,7	7,1	5,8	18,7	31,6
120—130	4,94	15,7	0,0	21,4	32,7	9,7	11,3	9,2	30,2
170—180	5,80	26,0	0,0	54,1	8,6	2,0	2,6	6,7	11,3
235—245	5,90	28,4	0,0	24,9	18,4	5,0	7,8	15,5	28,5
300—310	5,30	28,2	0,0	23,9	18,3	3,9	7,6	18,1	29,6
390—400	4,00	14,0	0,0	14,1	24,0	8,9	11,8	27,2	47,9

Note: Comma represents decimal point.

Table 8

Several chemical properties of southern chernozem, changing into dark-chestnut soils (Profiles 2, 3) and dark-chestnut soils (Profiles 6, 9)

Profile No.	Depth, cm	pH of water	CO_2 in %	Humus, % (according to Tyurin)	Total nitrogen, % (according to Kjeldahl)	Adsorption capacity, meq (according to Zakharchuk)
2	0—18	8,0	0,32	3,05	0,250	34,88
	22—32	7,8	0,25	2,50	0,205	37,24
	40—50	8,5	5,53	1,80	0,142	29,43
	70—80	8,6	6,82	1,12	—	22,78
	115—125	8,6	5,64	—	—	23,93
	141—151	8,8	7,24	—	—	14,21
	210—220	8,5	6,95	—	—	14,44
	265—275	8,5	9,80	—	—	14,25
	320—330	8,8	6,24	—	—	20,41
	380—390	8,6	—	—	—	19,81
3	0—20	7,9	0,31	3,24	0,282	32,46
	20—30	7,8	0,48	2,10	0,184	35,00
	45—55	8,3	7,85	1,01	0,09	28,41
	55—65	8,5	8,40	0,8	—	28,81
	90—100	8,7	9,25	0,6	—	21,16
	145—155	8,6	7,46	—	—	15,42
6	0—25	7,7	0,20	2,50	0,132	27,02
	30—40	7,8	0,20	1,54	0,196	34,82
	45—60	7,9	6,50	0,96	0,098	36,55
	80—90	8,2	9,32	—	—	20,41
	120—130	8,4	8,36	—	—	21,82
	170—180	8,1	6,50	—	—	13,96
	235—245	8,1	4,80	—	—	14,19
	300—310	8,1	5,54	—	—	18,92
	390—400	8,2	4,90	—	—	19,43
9	0—20	7,8	0,15	2,50	0,152	—
	25—35	7,9	0,15	1,99	0,141	—
	45—55	8,2	6,50	1,05	0,087	—
	80—90	8,1	7,20	0,78	—	—
	120—130	8,2	8,75	0,64	—	—

Note: Comma represents decimal point.

diameter along the profile is only observed in e salt-bearing horizons.

The foregoing data on particle-size analyses gree with data on adsorption capacity (Table 8) nd hygroscopic moisture (Table 6).

Texturally (Table 7), dark-chestnut soils re heavy clay loam-like and clay-dusty. Their osses are high on treatment, as a result of hich they seem lighter than southern chernoems which are in the process of transition to ark-chestnut soils. The content of particles 0.001 mm in the humus horizon (33.3%-35.6%) s smaller than in Profile 2 (which is associated ith more scant vegetation) and rapidly dereases with depth. The change in the clay raction content is related to solonization and e presence of layers rich in salts. This is lso substantiated by data on absorption apacity (Table 8) and hygroscopic moisture Table 7).

On the basis of what was said previously, we ay conclude that the soils described have both hernozem and chestnut soil features. These ransitional soils are similar to dark-chestnut oils in that they have a low humus content, a arbonate and gypsum horizon at a shallow epth and residual solonetzization. Sometimes e humus horizon is well-developed, humus inrusions occur in the form of pockets and tongues t a depth of 60-80 cm, the structure is blockyranular and the profiles are burrowed, all is making these soils similar to chernozems.

The soils examined must apparently be lassified as transitional under the conditions of e Crimean steppe. In relation to this the uestion arises of changing the boundaries of pically southern chernozems on the soil map, hich, according to our data, is traced more to e north than it actually is.

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BIBLIOGRAPHY

1. ANTIPOV-KARATAYEV, I.N. and L.I. PRASOLOV. 1953. Soils of the Crimean State forest reservation and adjacent areas. Trudy Pochvennogo instituta im. V.V. Dokuchayeva Akad. Nauk SSSR. Leningrad.

2. ANTONOVA, M. A. 1927. Soils of the Crimean experiment station and its surroundings. Fondy k. f. Akad. Nauk USSR.

3. GUSEV, V.P. and V.G. KALINICHENKO. 1955. Soils of the Crimean State complex agricultural experiment station and adjacent areas. Trudy Krymskoy gosudarstvennoy sel'skokhozyaystvennoy stantsii. Vol. 1. Krymizdat.

4. DZENS-LITOVSKAYA, N.N. 1952. Geographical characteristics of soil formation in the Crimean steppe. Vestnik Leningradskogo Gosudarstvennogo Universiteta. No. 7.

5. DOKUCHAYEV, V.V. 1948. Russian chernozem. Selected works. Vol. 1. OGIZ.

6. DUKAREVICH, B.I. 1955. Short agricultural characterization of the area of the station. Trudy Krymskoy gosudarstvennoy sel'skokhozyaystvennoy opytnoy stantsii. Vol. 1. Krymizdat.

7. IVANOVA, YE.N. and N.N. ROZOV. 1958. Experimental classification of soils in the steppe zone of the USSR. Pochvovedeniye, No. 12.

8. KLEPININ, P.I. 1935. Soils of Crimea. Krymizdat.

9. LEVAKOVSKIY, I.F. 1881. Investigation on the formation of the Taurida Mountains. Trudy Khar'kovskogo Universiteta.

10. POPOVA, T.V. 1959. Characteristics of southern chernozems of the Crimean steppe. Pochvovedeniye, No. 4.

11. PENYUGALOV, A. 1930. The climate of Crimea. Simferopol'.

12. RUPREKHT, F.I. 1866. Geobotanical investigations of chernozem. Vol. 10. Izdaniye Akad. Nauk.

13. SOKOLOV, N.N. 1929. Certain new data on the relief and soils of Crimea. Krym. No. 1(9). GIZ.

SOIL TILLAGE AND THE UTILIZATION OF NITROGEN AND PHOSPHORUS BY WINTER WHEAT

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The agronomical literature sufficiently covers the problem of the influence of deep soil tillage and plowing for changing soil conditions for plant life (4, 8, 10 and others) on the growth and development of the root system and vegetative and reproductive organs (5, 6, 8) and on the quality of yield. The problem of reducing weeds through soil cultivation has been solved. At the same time, plant physiologists do not study enough the processes taking place in plants during the growing period in relation to tillage, while specialists in agriculture pay attention only to phenomena taking place in soil and the final yield and are little interested in plants and processes taking place in them under given methods of tillage.

The clarification of the problem of the influence of soil tillage on plants during the growing period would allow finding proper ways of further improving agricultural practices and the crops grown.

Let us dwell briefly on the literature on this problem. Beloshapko (1) showed that when the plowed layer of sod-podzolic soils was increased from 16 to 23 cm, the accumulation of nitrogen in the mass of green manure increased by 34.7% for a mixture of mustard and buckwheat and 49.8% for lupine. The deepening of the plowed layer increased the amount of nitrogen in the grain crops, which was noted by Nalivkina (9) for a series of spring wheat varieties. Yartseva, Morozova and Lototskaya (11) found an increase in the content of phosphoric acid and potassium in the green mass of perennial grasses under the same soil climate conditions.

A brigade of the V. V. Dokuchayev Soil Institute, Academy of Sciences, USSR, which comprehensively studied the new agricultural method of T. S. Mal'tsev, notes that when this method is used, which requires deep plowing without a moldboard, a change in the oxidation-reduction potential (root) in plants and an improvement of the uptake of nitrogen by plants occurs. No change in the uptake of potassium and phosphorus occurs (3).

There are several works of foreign authors on the influence of tillage on plants. Singh (12) established the influence of soil tillage on the absorption of nitrogen and crop growth. Lawton and Browning (14), who studied the influence of various methods of soil tillage on the content of nutrients in corn and its yield on various soils, showed that plowing increases the nitrogen and potassium uptake by plants, as a rule, as compared to discing. Taylor and Johnson (13) found that normal spring plowing leads to an increase of the nitrogen content in the leaves of grain crops grown after alfalfa, as compared to shallow plowing; this was not observed in crops grown where grain crops were grown before. There was no difference in the content of phosphoric acid, while a difference in the amount of potassium was only observed during dry years. The literature shows that soil tillage has a noticeable effect on the organism of plants.

The present article describes the results of studies on the utilization of nutrients by winter wheat in relation to the depth of tilling of chestnut soil.

Laboratory-field and field tests were made in the experimental field of the Agricultural Institute of Kherson and at the Agrobiological Station of the Pedagogical Institute of Kherson. Productivity experiments were made in kolkhozes. The tests were repeated 3-4 times, except for the productivity experiments. Winter wheat plants were taken from the field during their various stages of life and immediately analyzed. The moisture content and nutrients available to plants were also determined at the same time. Nitrogen in the plants was determined according to the method of Kjeldahl, phosphorus was determined calorimetrically according to the method of Denige, and nitrates in the soil were determined by the method of Grandval'-Lyazhu.

Let us examine the data obtained in each individual experiment. The experiments at the Agricultural-biological station of the Pedagogical Institute were begun in the spring of 1956 to study soil tillage to a depth of 20, 35 and 40 cm. In the fall of 1956 four winter wheat varieties were sown after the preceding crop was harvested. Odessa 16 winter wheat was sown on a melon field and the following results were obtained. In spite of the great moisture consumption by the preceding crop, its useful amounts during the period of analysis in the fall were 767 m³/ha in the upper 60 cm from the surface with normal plowing, 851 m³/ha with deep plowing to 35 cm and 873 m³/ha with deep plowing to a depth of 40 cm. The nitrogen content was 5.85, 6.78 and 7.0 mg/kg of soil and that of phosphorus 5.9, 19.3 and 21.7 mg/kg of soil, respectively.

Table 1

Influence of deep plowing on the content and uptake of nitrogen and phosphorus by OD-16 wheat in 1956-1957, % of dry mass

Plant organ	Date	Phase	Nitrogen			Phosphorus		
			Depth of plowing, cm					
			20	35	40	20	35	40
Leaf	Nov. 16, 1956	Tillering	4,30	4,39	4,90	0,577	0,612	0,715
	April 8, 1957	Tillering	2,55	2,49	3,09	0,555	0,641	0,641
	May 21, 1957	Heading	2,11	2,73	3,20	0,438	0,444	0,447
Tillering node	June 16, 1956	Tillering	3,00	3,06	3,51	0,870	0,884	1,013
	April 8, 1957	Tillering	3,84	4,05	4,55	0,670	0,698	0,767
Stem	May 21, 1957	Heading	1,10	1,12	1,33	0,386	0,364	0,322
Spike	May 21, 1957	Heading	1,62	1,81	1,86	0,619	0,514	0,531
Utilization by one plant, mg								
Entire plant	Nov. 16, 1956	Tillering	7,17	7,01	8,93	1,12	1,21	1,66
Entire plant	April 8, 1957	Tillering	8,42	9,32	9,82	1,59	1,73	1,83
Entire plant	May 21, 1957	Heading	25,10	33,87	84,11	8,08	9,69	14,37

Note: In soil plowed to a depth of 40 cm, plants had considerably more secondary stalks.

Note: Comma represents decimal point.

The amounts of nitrogen and phosphorus in e growing period did not exceed the limits of xperimental errors and could not be used to dermine the nutritional regime of plants.

The analysis of plants during the periods of intering, tillering and heading stage shows the ositive role of deep tillage in the supply of nitrogen and phosphorus to plants (Table 1).

Data in Table 1 show that as the depth of soil tillage is increased the nitrogen content (as reduced to P_2O_5) in the leaves and tillering nodes increases. The content of phosphorus, on the other hand, in the stem and heads decreases during the heading period, while the total utiliza-

Table 2

Content of available nutrients in soil under winter wheat in 1956 (in mg/kg of soil)

Depth of plowed layer in spring, cm	Soil layer	Date of analysis			
		Nov. 9, 1956	Apr. 14, 1957	May 20, 1957 Heading	June 25, 1957 Ripening
		Tillering			
Nitrates					
20	0-10	58,3	4,9	6,3	7,3
	10-30	82,0	4,4	7,8	4,4
40	0-10	38,9	6,0	5,0	5,1
	10-30	43,9	4,5	4,8	5,1
Phosphorus (P_2O_5)					
20	0—10	4,60	0,12	0,04	1,72
	10—30	12,30	0,01	0,02	
40	0—10	4,50	0,11	0,04	0,24
	10—30	4,64	0,05	0,03	6,17

Note: Comma represents decimal point.

Table 3

Influence of deep tillage of fallow on the nutrient content in the plant organs, % of dry mass. Stalin kolkhoz, 1957

Depth of tillage of early fallow in 1956, cm	April 18, tillering			May 20, heading			
	Plant organ						
	Leaf	Tillering node	Average	Leaf	Stem	Spike	Average
	Nitrogen						
20	3,43	2,64	3,15	3,03	1,28	1,59	1,87
40	4,31	2,72	3,70	3,38	1,60	2,06	2,37
	Phosphorus (P_2O_5)						
20	0,86	1,00	0,94	0,69	0,65	0,64	0,66
40	0,96	1,02	1,00	0,80	0,74	0,69	0,75

Note: Comma represents decimal point.

Table 4

Influence of deep plowing on the content (%) of nitrogen in the plant organs, yield and quality of OD-3 winter wheat grains

Depth, cm	Flowering, May 30, 1956			Quality of grains, Jun.18,1956		Grain yield, cntr/ha	Nitrogen removal in the grain yield, kg/ha
	Nitrogen content in the plant organs			Absolute weight, g	Protein content, %		
	Leaf	Stem	Spike				
17	1,33	0,57	1,04	30,9	14,20	12,1	24,7
22	1,61	0,60	1,02	31,3	14,70	14,2	30,1
27	1,75	0,60	1,08	31,5	14,02	15,7	31,7

Note: Because of the poorly developed humus horizon, the soil could not be tilled deeper.
Note: Comma represents decimal point.

tion of nitrogen and phosphorus increases. We must point out that the ratio of nitrogen and phosphorus is wider in deeply tilled soil. For each weight unit of phosphorus utilized during the heading period, a plant used 6.9 units of nitrogen from normally plowed soil, 8.24 units from soil plowed to a depth of 35 cm and 13.72 units from soil plowed to a depth of 40 cm.

The higher the nutrient supply, the higher the yield and its quality. The grain yield in this experiment was 29.8 cntr/ha on soil plowed to a depth of 40 cm, 28.5 cntr/ha on soil plowed to a depth of 35 cm and only 25.1 cntr/ha on the control plot. The straw yield was 67.8, 64.6 and 61.4 cntr/ha, respectively. The protein content during the period of full ripeness was 13.98% on soil plowed to a depth of 40 cm, and 12.23% on soil plowed to a depth of 35 cm and on the control plot. It must be noted that the plants had a longer growing period (3-4 days) on deeply plowed soil, which resulted in a longer period of synthesis of organic substances. To substantiate this we must note that in the last 6 days the protein content in the grains increased by 0.72% on soil plowed to a depth of 45 cm, by 2.1% on soil plowed to 35 cm and by 0.51% on the control plot. Similar results were obtained for three varieties of winter wheat sown where corn was grown before.

Odessa 3 winter wheat was sown in the Stalin kolkhoz in the Golopristan' district of Kherson Region on early fallow turned over to a depth of 20 and 40 cm.

Along with plant analysis, the content of nitrates and water-soluble phosphoric acid in the soil was determined (Table 2).

The data in Table 2 show that the content of nitrates and phosphorus in the upper layer in the fall is much higher on normally plowed soil than on deeply plowed soil. This can be explained, on the one hand, by the fact that in the deeply plowed area, part of the nutrients was removed to deeper layers as a result of better water penetration and, on the other hand, by the more intense utilization of these nutrients by plants. The latter is substantiated by the higher nitrogen content in the plant organs. Thus, the average nitrogen content in plants before wintering (Nov.

Table 5

Influence of the deep tillage of the layer of perennial grass on the content of nitrogen and phosphoric acid in the plant organs of winter wheat under irrigated conditions. Educational farm No. 1, Agricultural Institute of Kherson, May 7, 1956

Depth of tillage in cm in 1954	Nitrogen		Phosphorus (P_2O_5)		Based on one plant, mg		Ratio of nitrogen; phosphorus in a plant
	Content in the organs in percent						
	Leaf	Average	Leaf	Average	Nitrogen	Phosphorus	
Without fertilizers							
20	4,60	3,36	0,805	0,821	11,54	2,55	9,85
30	4,75	2,75	0,700	0,714	13,05	2,85	10,83
35	4,63	3,12	0,718	0,743	14,15	2,58	12,93
5 metric ton/ha of manure and 1 cntr/ha of superphosphate applied in 1954 to soil plowed in the fall and applied in the spring of 1953 to soil cultivated for seeding							
20	5,08	3,25	0,819	0,890	23,06	4,45	12,24
30	5,22	3,34	0,742	0,823	27,37	4,89	13,23
35	5,36	3,32	0,802	0,882	27,54	5,01	13,00

Note: Comma represents decimal point.

, 1956) was 4.47% on deeply plowed fallow and .14% on the control plot. During this period ach plant used 4.23 and 3.97 mg of nitrogen, espectively. There was no great difference in ie content of phosphoric acid and each plant on eeply plowed soil absorbed 1.24 mg of P_2O_5, nd on the control plot, 1.3 mg.

As may be seen from Table 2, the content of utrients in the soil in spring was insignificant nd could not be used to determine the advanages of a given method of tilling. Plant analyses iade during the period of spring tillering and eading indicate that the supply of nutrients to lants is better in these periods (Table 3).

By April 14, each plant had used 22.7 mg of itrogen on deeply plowed soil and 16.7 mg on the ontrol plot and the amount of phosphoric acid sed was 5.0 and 6.1 mg,respectively. At the eginning of the heading period the uptake of itrogen was 77.8 and 43.9 mg and that of phosoric acid, 29.7 and 18.3 mg, respectively. As result of this, plants grew and developed beter on deeply plowed soil, had more leaves, igher productive tillering and had more chloroyll in their leaves. The content of raw chloroyll in the leaves of plants on deeply plowed oil in the fall was 47.7% higher, in spring 9% gher, and during the heading period 23.7% gher than on the control plot. Maximum ılorophyll content was recorded during the eading period. All this was reflected in the eld, which, in spite of the drought at the end June, was 2.7 cntr/ha higher on deeply plowed oil than on the control plot (32.3 cntr/ha). As result of the retardation of ripening on the eeply plowed soil, the absolute weight of the ain was 3.7% lower than on the control plot 9.93 g). Drought did not slow down the moveent of nitrogen into the grains. The protein ontent in the grain on deeply plowed soil was .22% as compared to 12.69% on the control plot.

The data of these two experiments agree with those obtained for Odessa 3 winter wheat, begun in 1956 by the agronomist N. S. Kravtsov at the T. G. Shevchenko kolkhoz in Skadov district. The soil under the winter wheat was plowed immediately after grain crops were harvested. The rains of June and August replenished the moisture contents. We made one analysis of plant organs, the results of which are given in Table 4.

All this agrees with earlier experiments made by us on winter wheat under irrigation conditions (2). Odessa 12 winter wheat was sown after irrigation and surface cultivation of the soil. The preceding crop was OD-10 corn which was sown after perennial grass sod was plowed to a depth of 20, 30 and 35 cm. The experiment was replicated 4 times. Table 5 shows the content of nitrogen and phosphoric acid in the plant organs during the stage of stem growth. The soil was irrigated at a rate of 600 m³/ha before seeding.

As the depth of cultivation was increased under preceding crops, the nitrogen content increased both against the background of fertilizers and without them. A decrease in the nitrogen content in the stem was observed on soil plowed to a depth of 30 cm as compared to the control plot and soil plowed to a depth of 35 cm when no fertilizers were used.

The content of phosphorus in the leaves and stems decreased when plowing depth was increased to 30 cm as compared to normal plowing. A further increase in plowing depth to 35 cm slightly increased the content of phosphoric acid as compared to plowing to a depth of 30 cm.

The total removal of phosphoric acid and nitrogen by one plant increased with a plowing depth of 30 cm. A further increase of plowing depth did not increase removal significantly, except for nitrogen in the absence of fertilizers. Fertilizers, even though they were applied 2-3 years previously, were still effective in increas-

Table 6

Effect of soil tillage on the grain yield of OD-12 winter wheat and its quality. Educational farm No. 1, Agricultural Institute of Kherson, 1956

Depth of tillage in cm in 1954	Grain yield, cntr/ha	Absolute weight of grains, g	Content	
			Protein, %	Nitrogen, kg/ha
Without fertilizers				
20	20,2	30,7	15,04	43,0
30	20,8	31,2	15,36	48,8
35	21,6	32,6	18,66	56,7
5 metric tons/ha of manure and 1 cntr/ha of superphosphate applied in 1952 to soil plowed in the fall and applied in the spring of 1953 to soil cultivated for seeding				
20	22,5	29,4	18,86	61,2
30	24,3	31,3	20,19	70,7
35	24,9	31,3	19,08	68,5

Note: Yield was calculated by the Agricultural Chair of the Agricultural Institute of Kherson, the analysis was made by the author.

Note: Comma represents decimal point.

ing the removal of nitrogen and phosphoric acid by plants (Table 6).

Because of the absence of irrigation during the growing period and the dryness during the second half of the growing period, the yield of winter wheat was comparatively low. The increase in the depth of plowing under the preceding crop had an effect on winter wheat, both with fertilizers and without them. As plowing depth is increased, the absolute weight of grain, the protein content and the removal of nitrogen in the grain yield increase.

Thus, it was established on the experimental basis that deep tillage of chestnut soils to a depth of 35-40 cm has a favorable effect on the utilization of nitrogen and phosphoric acid by winter wheat. The better supply of nitrogen and phosphorus to plant on deeply plowed soil promoted the development and growth of the plants and the synthesis of organic substances, which resulted in an increase of yield and an improvement of its quality.

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BIBLIOGRAPHY

1. BELOSHAPKO, M.K. 1940. Green manure and deep plowing of sod-podzolic soil. Zhurnal "Sovetskaya agronomiya." No. 8-9.

2. BILENKO, P.YA. 1956. Deep plowing and processes taking place in soil and winter wheat during irrigation. Naukovi zapiski Kherson'skogo pedagogichnogo institutu im. N.K. Krups'koy. No. 7.

3. GENKEL', P.A., I.N. ANDREYEVA, K.G. YERMAKOVA, and I.V. TSVETKOVA. 1957. Principal features of wheat physiology under the new system of soil tillage. Izvestiya Akad. Nauk SSSR, ser. biologicheskaya. No. 4.

4. IVANOV, P.K. 1949. Deepening of the plowed layer on chernozem soils. Dissertation for a doctor's degree in agricultural sciences, Bezenchuk experimental station.

5. IZMAIL'SKIY, A.A. 1881. Influence of deep tillage on the initial development of rye and wheat seedlings. Kherson.

6. KUKOLEV, N.I. 1950. Increase of soil fertility by the deepening of the plowed layer. Krasnodar.

7. LYSOGOROV, S.D. 1952. Characteristics of the development of cotton and the principal problems of its cultivation in the new regions of the USSR. Nauchnyye zapiski Khersonskogo Sel'skokhzyaystvennogo Instituta im. A. D. Tsyurupa. No. 4. Kherson.

8. MOSOLOV, V.P. 1954. Works. Vol. 4. Moscow.

9. NALIVNIK, A.A. 1951. Deepening of the plowed layer and spring wheat varieties. Trudy Saratovskogo Sel'skokhozyaystvennogo Instituta. Vol. 12. Saratov.

10. CHIZHEVSKIY, M.G. 1952. Depth of plowing and the deepening of the plowed layer on sod-podzolic soils. Sovetskaya agronomiya. No. 11.

11. YARTSEVA, A.K., A.V. MOROZOVA, and YE.A. LOTOTSKAYA. 1956. Soils in the experimental plots of the Stepanovskoye sovkhoz, Bronnitskiy district, Moscow Region, and change in their agronomical properties after deepening of the plowed layer. Trudy Pochvennogo instituta im. V.V. Dokuchayeva Akad. Nauk SSSR. Vol. 49.

12. SINGH, K. 1952. Effects of soil cultivation on growth and yield of winter wheat. V. Effect of cultivation on the nitrogen uptake and growth of crop in unfertilized and fertilized soils. J. Sci. Food. Agric. Vol. 3:570-579.

13. TAYLOR, G.S. and W.H. JOHNSON. 1956. Tillage studies with corn on an Ohio Lakebed clay soil. Soil Sci. Soc. America Proc., 20(2):274-278. (Abstract journal "Biologiya", 1957, 45745).

14. LAWTON, K. and G.M. BROWNING. 1954. Influence of the method of soil tillage on the content of nutrients in corn and its yield. In the collection: "Agriculture abroad." No. 4. Moscow.

NCIENT LANDSCAPES OF MOSCOW ACCORDING TO A SPORE ND POLLEN ANALYSIS

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The spore and pollen analysis is widely used
present for solving theoretical and practical
oblems in the fields of geology, palaeontology,
cheology, etc. The results of the analysis
y be also used for solving a series of prob-
ns in the field of soil science, first of all the
dy of buried soils in order to determine the
nplex of natural conditions under which they
med.

For a wider use of pollen analysis in solving
oblems related to the soil genesis it is im-
tant to elaborate the method of sampling and
work out methods for interpreting data of the
ore and pollen analysis as related to a de-
ite series of problems, for instance, the
oblem of the preserving and washing of pollen
soil.

In this article we will give the results of the
len analysis of buried soils discovered dur-
the digging of a hole in the Zaryad'ye area
Moscow.

The analysis was made of a soil layer 195
thick (described by K. P. Bogatyrev) which
s to a depth of 385 cm.

Trench No. 5.

0-15 cm. Dark-gray, clay loam rich in
ris from construction, containing tile and,
he lower part, chips and birch bark. Transi-
is abrupt.

15-53 cm. Dark-grey, almost black, fine
y loam, gravel with wood charcoal in places,
taining tiles (clay) in the lower part. Transi-
is abrupt.

53-71 cm. Darkish-brown clay loam.
uptly replaced by the underlying horizon.

71-87 cm. Unevenly colored—from gray to
k-gray, uneven texture—from clay loam to
d (in spots). Abrupt transition.

37-112 cm. Gray sand with small lenses of
k-grey clay loam with sand. Abruptly re-
ced by the next horizon.

112-125 cm. Darkish-gray clay loam with a
k cinnamon-brownish tinge, contains black-
spots. Abruptly replaced by the next hori-

125-145 cm. Darker clay loam, containing chips. Comparatively abrupt by the next horizon.

145-155 cm. Same clay loam, slightly gleyed.

155-195 cm. Dark sand with occasional pebbles (black flint). All the horizons are very moist and the lower horizon is wet.

As may be seen from the morphological description, the buried humus horizons of the soil are enriched by chips, tile, etc., which indicates that they have been turned over so that no conclusions as to their genesis can be made from their outward appearance (humification, thickness). In this case pollen analysis is the only method which can reveal the natural conditions of formation of these buried soils, the age of which in this case is determined by archeologists.

Altogether six samples were analyzed.[1] The results of the analysis are given in the graph of the general composition of woody and non-woody spores and pollen.

Sample 6, depth 155-195 cm. The number of pollen grains counted in the sample was 377. In examining the graph of the general composition of pollen, one may see that spores predominate in the spore-pollen spectrum, the second place is occupied by woody pollen and the third, by pollen of non-woody plants. The analysis of the composition of woody pollen shows the dominating role of conifers (pine and spruce) with a small admixture of deciduous species (oak, basswood, hornbeam, birch and hazelnut). Among pollen of non-woody plants the first place is occupied by pollen of mixed herbs and grasses. Mixed herbage pollen is mainly represented by pollen of the phlox family, the madder family, the cruciferae family, saxifraga family, and the Umbellales. It is interesting to note that in this horizon several pollen grains of Stratiotes of the family of Hydrocharitaceae, which are widely distributed at present in temperate latitudes, were found

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[1] Prepared samples were given acetolysin method, determination and counts by pollen grains were with enlargements at 10 x 20 and 10 x 40.

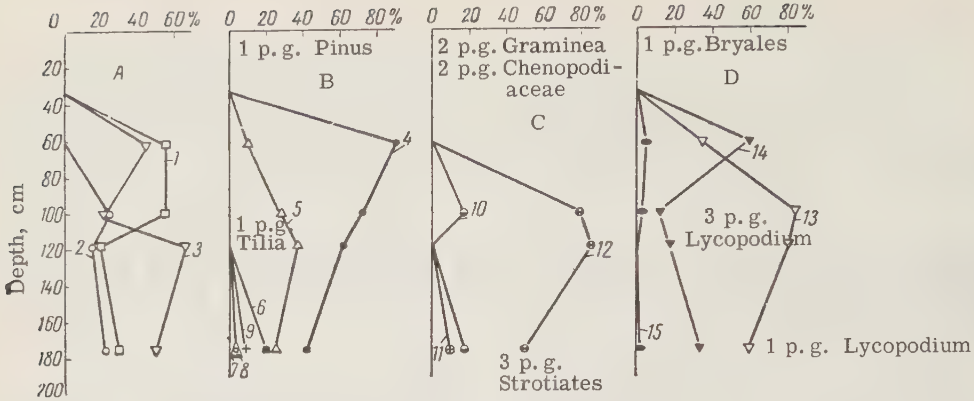

Fig. 1 - Composition of pollen and spores in the buried soil.

A - general composition; 1 - woody pollen; 2 - non-woody pollen; 3 - spores. B - woody pollen: 4 - Pinus; 5 - Picea; 6 - total number of Quercus pollen; Tilia; 7 - Betula; 8 - Carpinus; 9 - Corylus. C - non-woody pollen; 10 - Giaminea; 11 - Chenopodiaceae; 12 - mixed herbs. D - spores: 13 - Bryales; 14 - Polypodiaceae; 15 - Sphagnales; p.g. - pollen grains.

among the pollen of non-woody plants. Stratiotes is a plant which tends to choke the waters of lakes, it produces pollen in large quantities which do not keep well because their exine is not very resistant. Therefore, finding pollen of this family is a rare phenomenon (3).

In contrast to other horizon, a considerable number of the goosefoot family Chenopodiaceae pollen was found in this horizon, amounting to 10% of all pollen of non-woody plants. Among the spores a dominant place is occupied by the spores of green mosses and ferns. Spores of sphagnum mosses amount only to 1% of the total spores.

The spore-pollen spectrum obtained belongs to the phase of mixed conifer and broadleaf forests and is close to the spectrum of the same phase as described by Grichuk (1, 2).

Sample 5, depth 112-125 cm. The number of pollen grains counted was 292. In analyzing the data on the general composition of the spectrum, one must note the increase in the number of spores and the decrease in the number of woody and non-woody pollen as compared to the preceding horizon. In the composition of woody pollen, pine (62%) and spruce (37%) predominate and pollen of broadleaf species is totally absent. The pollen spectrum of non-woody species is represented in this horizon exclusively by mixed herbs. The number of spores of green mosses continues to increase, while that of ferns decreases. Spores of sphagnum mosses are totally absent in this horizon. All this gives enough basis to assume that the vegetation of this area was close to that of the present-day vegetation of conifer forests and was probably very sparse.

Sample 4, depth 87-112 cm. The number of pollen grains counted in this sample was 249. This spectrum differs from the preceding by the sharp change of the percentage relationship in the general composition. The dominating place is now occupied by the pollen of woody plants (55%), the second place, by pollen of non-woody plants (24%), while spores amount to 21% of the total. There is a complete absence of pollen of broadleaf species among woody pollen, an increase of spruce pollen from 62% in the preceding horizon to 72% and a decrease of spruce pollen from 37% to 28%. Grass pollens appear again among pollens of non-woody plants, but the first place is occupied by mixed herb pollens, as before. Spores of green and sphagnum mosses predominate among the spores and there are less fern spores.

As a result of the spore and pollen analysis one may assume that during the period of deposition of this horizon, the vegetation of the area was close to that of contemporary conifer forests.

Sample 3, depth 53-71 cm. The number of pollen grains counted in the sample was 89. The composition of the spore and pollen spectrum is similar to that of the preceding horizon and differs from it only by the absence of non-woody pollen and a certain increase in the amount of spores. Analysis of woody pollen indicates a regular decrease of the amount of spruce pollen from 28% in the preceding horizon to 10% and an increase in the number of pine pollen (from 72%-90%). Spores are mainly represented by fern, green and sphagnum mosses. In examining the spectrum we reach the conclusion that by its composition it belongs to the spectrum of coniferous forests with contemporary vegetation.

Sample 2, depth 15-53, and sample 1, depth 0-15 cm. The percentage composition of pollen could not be determined because of the insufficient amount of pollen grains.

In examining the characteristics of the spore and pollen spectra of various horizons of the buried soil we must note the changes in their composition. These changes reflect the influence of climatic variations on the composition of vegetation and indicate a change in climate from a milder one (during the period corresponding to the lower horizon) to a cooler one (in the upper rizons).

The data obtained by the spore and pollen
lysis are substantiated by the first informa-
n available on the vegetation and climate of
scow which is contained in chronicles. Thus,
instance, in order to settle in the area and
ablish fields, the first settlers had to clear
lense taiga. In 1330 Ivan Kalita built the
urch of Christ in the Forest in the area of the
emlin. The name of the church shows that
this time there were still pine forests in the
ea. This is also indicated by such names as
rovitskiye (Forest) gates, the church of John
Baptist in the Woods, etc.

According to the Voskresensk chronicle,
m 1339 the Kremlin was surrounded by an
wall. "The remains of oak logs 'an arshin
thickness' which were found during the con-
uction of the Great Kremlin Palace testify to
fact that oaks grew in abundance in the vi-
ity; it is doubtful that such logs could be
ought by the builders from afar." (Sobolev,4).

In conclusion we may say that the small num-
of samples and their insufficient pollen content make a more detailed and accurate reconstruction of the nature of old Moscow difficult.

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BIBLIOGRAPHY

1. GRICHUK, V.P. and YE.D. ZAKLINSKAYA. 1948. Analysis of buried pollen and spores and its application in palaeogeography. Geografgiz.

2. GRICHUK, V.P. 1950. Vegetation of the Russian plain in the lower and middle Quaternary period. Trudy Instituta geografii. Materialy po geomorfologii i paleogeografii SSSR 46(3). Izd. Akad. Nauk SSSR.

3. ZAKLINSKAYA, YE.D. 1950. Morphological description of the pollen of grass and certain shrub vegetation according to families. In the book: Pollen analysis. Izd. geologicheskoy literatury. Moscow.

4. SOBOLEV, L.I. 1947. Vegetation. In the book: The nature of the city of Moscow and the Moscow region. Izd. Akad. Nauk SSSR. Moscow—Leningrad.

DETERMINATION OF NITOGEN, PHOSPHORUS AND POTASSIUM IN PLANT MATERAL FROM A SINGLE SAMPLE

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Nitrogen, phosphorus and potassium are the main elements of plant nutrition, so that in the analysis of agricultural crops these three elements are determined first.

In methodological instructions for the analysis of plants (5, 9, 12, 18) it is usually recommended that nitrogen, phosphorus and potassium be determined from three separate samples. Nitrogen is usually determined by oxidation of a plant sample by the Kjeldahl method, using various catalysts (metallic mercury, selenium, $CuSO_4$; mixtures of catalysts, such as $CuSO_4$ + K_2SO_4 (Na_2SO_4); $CuSO_4$ + K_2SO_4 + SeO_2, etc.). P_2O_5 is determined by semi-ashing in a muffle furnace, adding to the plant mass, to reduce the escape of phosphorus, a solution of Ca(Mg) acetate, or by wet ignition in a mixture of concentrated acids (H_2SO_4 + HNO_3, etc.). K_2O is determined by dry ashing; extraction in a hot water bath, or hot dilute HCl (0.01 N), and also extraction of potassium in the cold — 1 N HCl (2).

There are certain proposals in the literature for faster methods of oxidizing plant material. Thus, Frear, Thomas and Edmiston (21) added $KMnO_4$ to H_2SO_4 to accelerate oxidizing plants in the Kjeldahl method, whereby the time of oxidizing one sample was reduced from 8-14 to 1-2 hours.

I. F. Golubev (4) recommends a mixture of H_2SO_4 and $KMnO_4$ for the decomposition of soil and peat, followed by the determination in the solution of nitrogen and phosphorus. It must be kept in mind, however, that in the combustion of plant material in a solution of H_2SO_4 + $KMnO_4$, we and other investigators (21) established a loss of nitrogen in a number of cases. The H_2SO_4 + H_2O_2 is also used for the combustion of plant material, which reduces the combustion time of one sample from 8-14 to 2-2.5 hours. Almost all elements, except sulfur and in certain cases phosphorus (when hydrogen peroxide contains a large amount of phosphorus) can be determined from the solution obtained. Using this method of plant combustion, Wolf and Ichisaka (22) determined five elements from one sample: N, P, K, Ca and Mg; Pinevich (10) determined two elements: N and P; and Kurkayev (7), three elements: N, P and K.

Recently a number of countries have been widely using mixtures of concentrated acids for wet ashing of plant material. In order to accelerate combustion 70%-72% $HClO_4$ or its salts ($KClO_4$, $NaClO_4$) are added to the mixture. Toth, Pringe, Wallace and others (20) oxidized plant material in a mixture of HNO_3 and $HClO_4$ (3:1) and determined eight elements — P, K, Na, Mg, Fe, Mn and S in the solution obtained. Lüders (16) used a mixture of HNO_3, $HClO_4$ and H_2SO_4 (40:4:1) to oxidize plants and determined five elements: P, Fe, Mn, Cu and Zn in the solution obtained. The foregoing methods exclude the possibility of determining nitrogen in the solution, since nitric acid is present in the mixture.

We verified the possibility of determining phosphorus and potassium along with nitrogen during the combustion of plants according to the Kjeldahl method; we made an attempt to use the accelerated method for combustion of plant material.

Combustion of plants by the Kjeldahl method (in the presence of the catalysts $CuSO_4$ or Se)

To 0.2 g of ground plant material in a Kjeldahl flask (100-ml capacity), 5 ml of concentrated H_2SO_4 and 0.1 g of copper sulfate (or 0.05 g of metallic selenium powder) are added; the mixture obtained is kept overnight after which the sample under study is oxidized as described in the instructions (5, 9, 12, 18). After the completion of combustion, the mixture is cooled and placed in 100-ml volumetric flasks which are then brought up to volume with distilled water and the content is stirred. The solution obtained is used to determine nitrogen, phosphorus and potassium. A detailed description of the method of determining these elements in the solution is given below (see: combustion of plants in a mixture of H_2SO_4 + $HClO_4$ + $CuSO_4$).

As may be seen from Table 1, nitrogen, phosphorus and potassium may be determined from a single sample of plant material when it is oxidized in a mixture of H_2SO_4 + $CuSO_4$. We established (Table 2) that in combustion of plants in a mixture of H_2SO_4 + Se, nitrogen and potassium may be determined from a single sample.

Hutton and Hye (14) determined N, P, K, Na,

Table 1

Determination of N, P, K from a single sample by combustion of plant material in a mixture of H_2SO_4 + $CuSO_4$, % of air-dried substance

Plant	Part of plant	N			P_2O_5			K_2O		
		H_2SO_4+Se	H_2SO_4+$CuSO_4$	Relative error of the analysis, %	Semi-dry ashing	H_2SO_4+$CuSO_4$	Relative error of the analysis, %	Dry ashing	H_2SO_4+$CuSO_4$	Relative error of the analysis, %
Corn	Leaf	1,62	1,60	—1,2	0,35	0,36	+ 2,8	0,64	0,61	— 4,7
Potato	Top	2,25	2,26	+0,4	0,46	0,48	+ 4,3	1,56	1,80	+15,2
Mustard	Leaf	1,38	1,36	—1,4	0,34	0,36	+ 6,0	3,29	3,27	— 0,6
Sudan grass	Stem	0,54	0,49	—9,3	0,17	0,15	—12,0	1,08	1,15	+ 6,5
Winter wheat	Grain	2,14	2,11	—1,4	0,65	0,70	+ 7,7	No data		
Winter rye	"	1,54	1,51	—1,9	0,98	0,96	— 2,0	0,53	0,59	+11,3
Millet	"	1,42	1,36	—4,2	0,75	0,79	+ 5,3	0,36	0,33	— 8,3

ote: Comma represents decimal point.

Table 2

Determination of N and K from a single sample by combustion of plant material in a mixture of H_2SO_4 + Se, % of air-dried substance

Plant	Part of plant	N	K_2O		
			Dry ashing	H_2SO_4+Se	Relative error of the analysis, %
Corn	Shoot	1,98	4,07	3,95	—2,9
"	Same	1,93	4,52	4,17	-7,7
Potato	Top	2,25	1,56	1,68	+7,7
Sudan grass	Stem	0,54	1,08	1,13	+4,6
Winter wheat	Grain	2,14	0,40	0,39	—2,5
Millet	"	1,42	0,36	0,35	—2,8

Note: Comma represents decimal point.

and Mg in the solution obtained from the
bustion of plants in a mixture of H_2SO_4 + Se.

Ashing of a Plant Mass in 60% $HClO_4$

long time ago investigators noted the valu-
properties of 70%-72% $HClO_4$, which, in
rast to waterless perchloric acid, is not
sonous, not explosive and stable (3, 8). Chlor-
cid is the strongest of all known acids. The
s of chloric acid (perchlorates), except for
w, dissolved readily in water. The oxidiz-
action of perchloric acid takes effect at
peratures near the boiling point (200°C).
chloric acid is widely used for oxidizing
ous substances, including organic sub-
ces. It may also be used for combusting
t material. Thus, Bobritskaya (1) used
$HClO_4$ for analyzing lithophilous plants.
used 60% $HClO_4$ for the analysis of various
cultural crops.

nalytical procedure. A 0.2 g sample of
nd plant material is placed in a Kjeldahl
k of 100-ml capacity; 10 ml of 60% $HClO_4$ is added to it and the mixture obtained is kept cool for 1 hour or overnight. At the same time two control flasks are prepared, containing only the reagents without the plant material. Then the flasks are put on a fire, in such a manner that the flame does not touch their bottom, and heated until complete destruction and oxidation of the organic matter, which is determined by the complete loss of color of the solution. The ashing of a single plant sample is completed in 20-40 min. After this, the mixture is cooled and placed in 100-ml volumetric flasks which are brought up to volume with distilled water and stirred. The solution obtained, designated as A, is used for the determination of nitrogen, phosphorus and potassium (see below).

Solution B. Twenty-five mls of the A solution is placed in 100-ml volumetric flasks which are then brought up to volume with distilled water, stirred, and the solution is used for determining potassium and phosphorus.

Nitrogen determination. Twenty-five mls of the A solution is taken for distilling of ammonia by the semimicro-Kjeldahl method (for details see below).

Determination of phosphorus. Two to ten mls of the B solution is placed in 50-ml volumetric flasks, diluted with water to 25-30 ml, two drops of the β-dinitrophenol indicator are added (saturated water solution) and the solution is titrated with 10% NH_4OH until a yellow coloration appears, which is then removed by the addition of 1-2 drops of 10% HCl or H_2SO_4. After this the phosphorus in the solution is determined colorimetrically using the method of Truog-Meyer (11) in an electrophotocolorimeter with a red filter (λ-656 mμ).

Potassium determination. It is determined in a flame spectrophotometer according to the method described by Ivanov (6) using the B solution. When the amount of potassium in a sample is small (grass seeds, etc.) it is determined from the A solution. The results of the analyses are given in Table 3. The data in this table show that the relative error of the analysis in the determination of phosphorus and potassium amounts to ± 1%-3% and rarely reaches 6%-10%.

The results of the determinations of the nitrogen content in plants were in all cases smaller than corresponding data obtained from the combustion of plants by the Kjeldahl method. This was especially pronounced in the analysis of grain, where the relative error of the determinations exceeded 10% and reached 17%-18% in a number of cases. In addition, there were discrepancies between the nitrogen content of parallel samples in the analysis of grain.

Nitrogen losses which occurred on oxidation of plant samples in 60% $HClO_4$ may be attributed to several causes. In the opinion of certain investigators (17) they may be caused by the decomposition of ammonium perchlorate, which forms during the process of oxidation of plant material in perchloric acid. In addition, it is known that hot perchloric acid, being a strong oxidizer, may at the same time be a weak reducer. Smith (19) showed that the decomposition of perchloric acid takes place in two directions simultaneously:

$$4HClO_4 \dashrightarrow 2Cl_2 + 7O_2 + 2H_2O \text{ — oxidizer} \tag{1}$$

$$2HClO_4 \dashrightarrow Cl_2 + 3O_2 + H_2O_2 \text{ — weak reducer} \tag{2}$$

The decomposition of $HClO_4$ takes place predominantly in the manner of the reaction type (1) and only a small part of it decomposes in the manner of the reaction type (2). The ability of hot $HClO_4$ to be simultaneously an oxidizer and a reducer results in that 72% $HClO_4$ alone cannot fully oxidize trivalent chromium to hexavalent chromium, trivalent cerium to tetravalent cerium, etc.

Proceeding from the foregoing peculiarities of $HClO_4$, we may assume that nitrogen losses on the oxidation of a plant sample in 60% $HClO_4$ are related to a partial reduction of ammonia, forming in the process of oxidation of the plant material, to N_2. Thus, on the basis of the data obtained, 60% $HClO_4$ may be recommended for

Table 3

Determination of N, P, K from a single sample by combustion of plant material in 60% $HClO_4$, % of air-dried substance

Plant	Part of plant	N			P_2O_5			K_2O		
		Kjeldahl method	$HClO_4$	Relative error of the analysis, %	Semi-dry ashing	$HClO_4$	Relative error of the analysis, %	Dry ashing	$HClO_4$	Relative error of the analysis, %
Sugar beet	Leaf	3,44	3,25	—5,5	1,65	1,63	—1,2	2,57	2,38	—0,74
"	Stem	1,18	1,15	—2,5	0,81	0,86	+6,2	4,55	4,13	—9,2
Potato	Leaf	3,37	3,14	—6,8	1,20	1,23	+2,5	1,53	1,51	—1,3
"	Stem	1,26	1,03	—18,0	0,56	0,57	+1,7	1,62	1,51	—6,8
Corn	Leaf	1,60	1,52	—5,0	0,28	0,29	+3,5	0,64	0,68	+6,2
"	Stem	1,03	0,92	—10,6	No data			0,36	0,39	+8,3
Millet	Leaf	1,52	1,49	—1,9	0,66	0,68	+3,0	1,49	1,60	+7,3
"	Stem	0,45	0,45	0,0	0,40	0,40	0,0	0,51	0,57	+11,7
"	Ear	1,82	1,75	—3,8	0,78	0,80	+2,5	No data		
Mustard	Stem	0,53	0,52	—1,8	0,84	0,87	+3,5	0,92	0,93	+ 1,1
"	Husk	1,26	1,18	—6,4	0,28	0,28	0,0	1,70	1,73	+ 1,7
Sudan grass	Leaf	2,34	2,29	—2,1	0,33	0,35	+6,0	1,83	1,86	+ 1,5
"	Stem	0,65	0,61	—6,1	0,17	0,19	+12,1	1,45	1,41	— 2,7
Alfalfa	Entire plant	2,58	2,35	—8,9	0,38	0,34	—10,5	1,50	1,45	— 3,3
"	Seed	5,70	5,05	—11,4	1,75	1,73	—1,1	1,30	1,31	+ 0,8
Winter rye	Hay	0,52	0,50	—3,8	0,21	0,22	+4,8	1,20	1,22	+ 1,6
"	Grain	1,48	1,23	—17,0	0,83	0,83	0,0	0,65	0,62	— 4,6
"	"	2,11	1,88	—10,9	0,88	0,96	+9,1	0,57	0,56	— 1,8

Note: Comma represents decimal point.

ng plant materials and determining phos-
rus and potassium in the solution (it is not
ommended that nitrogen be determined). This
hod reduces considerably the time required
he combustion of one sample (20-40 min
ompared to 3-6 hours).

mbustion of Plant Material in a Mixture of
Concentrated H_2SO_4 + 60% $HClO_4$ + $CuSO_4$

. Smith (19) notes that the full oxidation of
ous substances with perchloric acid may
chieved with a mixture of perchloric acid
concentrated sulfuric acid. The ratio of
e acids in the mixture is determined experi-
tally for various substances. For deter-
ing total nitrogen in various organic sub-
ces (primarily of protein origin) Mears and
sey (17) establish the amount of 72% $HClO_4$
h can be present in a mixture with concen-
ed H_2SO_4 without causing nitrogen losses
ml of concentrated H_2SO_4 + 2 ml 72% $NClO_4$
g $CuSO_4$ were added to 1 g of organic
erial). The addition of more than 2 ml $HClO_4$
e mixture usually led to the loss of nitro-
Mears and Hussey pointed out the fact
the method proposed by them considerably
elerates the combustion of organic sub-
ces as compared to the Kjeldahl method (from
0 hours to 15-20 min).

relation to this we tried (with minor modi-
ions) to use the method of Mears and
sey for the analysis of various agricultural
s, and determined, from the solution ob-
ed after combustion, phosphorus and potas-
in addition to nitrogen.

nalytical procedure. Immediately before
bustion a mixture of H_2SO_4 + $HClO_4$ is pre-
d in such a manner that for each 5 ml of
entrated H_2SO_4 there will be 0.5 ml of 60%
O_4. A 0.2 g sample of ground plant material
aced in a Kjeldahl flask of 50-100 ml capacity
5.5 ml of the mixture of H_2SO_4 with $HClO_4$
.1 g of $CuSO_4 \times 5H_2O$ salt is added to it.
e same time two flasks are prepared which
ain the reagents without the plant mass; the
tion obtained serves as a control for the
ty of the reagents used in the analysis. The
ure is left to cool for 30-60 min (it is not
mmended that it be left overnight), then the
s are placed on a gas burner covered with
stos and allowed to warm for 5-7 min until
mogeneous cinnamon-brownish paste forms.
r this, combustion is continued on an open
e until the solution becomes transparent
light blue in color. The combustion of one
le takes 15-20 min. After the completion
hing, the mixture is cooled, transferred
0-ml volumetric flasks, brought up to vol-
with distilled water, and stirred. The solu-
obtained after combustion is conditionally
ted with the letter A and is used as the initial
ion for the further determination of nitrogen,
phorus and potassium (see below).

olution B. Twenty-five ml of the A solution
aced in 100-ml volumetric flasks, brought
volume with water and stirred. Solution
rves for the determination of phosphorus and
ssium.

itrogen determination. Twenty-five ml of the A solution is taken and ammonia is distilled in the micro-Kjeldahl apparatus (12). The distilled ammonia is absorbed by 0.02 N H_2SO_4. Excess acid in the collecting vessel is titrated with 0.02 N NaOH in the presence of 4-5 drops of the Groag indicator until the color of the indicator changes from red-violet to gray and to green.

Preparation of the Groag indicator. To 100 ml of a saturated alcohol solution of methyl red 4 ml a 1% aqueous solution of methylene blue is added.

Potassium determination is made in solution B or A (depending on the amount of potassium in plant material) on flame photometer.

Phosphorous determination. Five to ten ml of the B solution is placed in 50-ml volumetric flasks, diluted with water to 25-30 ml, two drops of the β-dinitrophenol indicator are added and the whole is titrated with 10% NH_4OH until a yellow color appears, which is later removed by the addition of 1-2 drops of 10% HCl or H_2SO_4. After this, phosphorus is determined in the solution using the colorimetric method of Truog-Meyer (10). It must be noted, however, that in spite of the fact that the B solution, which is used for determining phosphorus, is colorless, the amount of copper it contains often interferes in the colorimetric determination of phosphorus. This is possibly due to the fact that copper, as well as phosphorus, may form with MoO_3 a heteropolyacid of the following composition: $H_{10}\,[Cu(MoO_4)_6]$. To eliminate the effect of copper on the colorimetric determination of phosphorus by the method of blue coloration, 5-10 ml of a control solution B (i.e., dilute control solution which contains all the reagents used in the analysis without the plant material, are added to the flasks containing standard phosphorous solutions. If the phosphorous content in the solution studied is determined from the normal scale, without the addition of $CuSO_4$, the data obtained are slightly too low, especially when a 50-ml solution contains more than 0.02 mg of P_2O_5.

The results of the analyses, which are given in Table 4, show that during the determination of nitrogen by the combustion of plants in a mixture of H_2SO_4 + $HClO_4$ + $CuSO_4$, the relative error of the analysis varied in most cases from 0 to ± 0.5%-1.8%.

The results of phosphorous and potassium determinations closely agree with data obtained by standard methods. The relative error of the analysis varied from ± 2%-6%.

Thus the method described allows rapid combustion of a plant material (15-20 min instead of 8-14 hr) and a sufficiently accurate determination (as compared to classical methods) of nitrogen, phosphorus and potassium in the solution. These characteristics of the proposed method greatly simplify the analysis of plants and make it possible to conduct mass determinations of the nitrogen, phosphorous and potassium content in various agricultural crops.

Table 4

Determination of N, P, K from a single sample by combustion of plant material in a mixture of $H_2SO_4 + HClO_4 + CuSO_4$, % of air-dried substance

Plant	Part of plant	N			P_2O_5			K_2O		
		Kjeldahl method	$H_2SO_4+HClO_4+$ $+CuSO_4$	Relative error of the analysis, %	Semi-dry ashing	$H_2SO_4+HClO_4+$ $+CuSO_4$	Relative error of the analysis, %	Dry ashing	$H_2SO_4+HClO_4+$ $+CuSO_4$	Relative error of the analysis, %
Beet	Stem	1,25	1,25	0,0	0,77	0,72	—6,5	4,55	4,41	—3,4
Mustard	Leaf	1,38	1,36	—1,4	0,34	0,36	+6,0	3,29	3,20	—2,7
Winter wheat	Grain	2,14	2,01	—6,5	0,65	0,70	+7,7	0,40	0,37	—7,5
Millet	"	1,42	1,36	—4,2	0,75	0,78	+4,0	No data		
Winter rye	"	1,54	1,52	—1,3	0,98	0,96	—2,0	0,53	0,56	+5,6
Sudan grass	Stem	0,54	0,55	+1,8	0,17	0,15	—12,0	1,08	1,10	+1,9
Potato	Top	2,25	2,25	0,0	0,46	0,48	+4,3	1,56	1,56	0,0
Corn	Shoot	1,98	1,99	+0,5	0,26	0,26	0,0	4,07	4,15	+2,0
"	Leaf	1,62	1,57	—3,1	0,35	0,36	+2,8	0,64	0,59	—7,8

Note: Comma represents decimal point.

Conclusions

1. During the combustion of plant materials by the Kjeldahl method in a mixture of H_2SO_4 + $CuSO_4$, phosphorus and potassium may be determined along with nitrogen in the solution obtained.

2. It is shown that during the combustion of plant materials in a mixture of H_2SO_4 + Se it is possible to determine nitrogen and potassium from a single sample.

3. The method of the wet ashing of plants in 60% $HClO_4$ allows sufficiently accurate and rapid determination of phosphorus and potassium from one plant sample. The duration of combustion of one sample is 20-40 min (instead of 3-6 hr).

4. A method of accelerated combustion of plants in a mixture of concentrated H_2SO_4 + 60% $HClO_4$ + $CuSO_4$ followed by the determination of nitrogen in the solution obtained is proposed. The duration of the combustion of one sample is 15-20 min (instead of 8-14 hr).

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BIBLIOGRAPHY

1. BOBRITSKAYA, M. A. 1951. Absorption of mineral elements by lythophylic vegetation from massive-crystalline rock. Candidate's dissertation. Library of the V. V. Dokuchayev Soil Institute, Academy of Sciences, USSR.

2. BOGDAN, YE. V. 1940. Extraction of potassium from plants by means of a hydrochloric acid extract. Trudy Pochvennogo Instituta im. V. V. Dokuchayeva Akad. Nauk SSSR, Vol. 21.

3. GILLEBRAND, V. F., G. E. LENDREL', G. A. BRAYT and D. I. GOFMAN. 1957. Practical manual of inorganic analysis. pp. 60-61. 789-791. Goskhimizdat.

4. GOLUBEV, I. F. 1937. A new method of determining total nitrogen in soils and peat. Pochvovedeniye, No. 10.

5. YERMAKOV, A. I., V. V. AVRASIMOVICH, and others. 1952. Methods of biochemical investigation of plants. Sel'khozgiz.

6. IVANOV, D. N. 1954. Methods of spectral analysis. In the book: Agrochemical methods of soil investigation. p. 239. Izdatel'stvo Akad. Nauk SSSR.

7. KURKAYEV, V. T. 1959. Accelerated determination of N, P and K in plants from a single sample. Pochvovedeniye, No. 9.

8. NEKRASOV, B. V. 1953. Course of general chemistry. pp. 239-246. Goskhimizdat.

9. PETERBURGSKIY, A. V. 1954. Manual of agrochemistry. pp. 16-136. Sel'khozgiz.

10. PINEVICH, V. V. 1955. Determination of nitrogen and phosphorus in plant material from a single sample. Vestnik Leningradskogo Universiteta. No. 1.

11. KHEYFETS, D. M. 1954. Methods of determining phosphorus. In the book: Agrochemical methods of soil investigation. p. 72. Izdatel'stvo Akad. Nauk SSSR.

SHESTAKOV, A. G. 1940. Instructions for practical exercises in agrochemistry. Part II. OGIZ — Sel'khozgiz.

CAVELL, A. J. 1954. A rapid method for the determination of nitrogen phosphorus and potassium in plant materials. J. Sci. Food and Agric. 5, pp. 195-200.

HUTTON, R. G., and P. H. HYE. 1958. The rapid determination of the major nutrient elements in plants. J. Sci. Food and Agric., Vol. 9, No. 1.

LINDNER, R. C. 1944. Rapid methods for some of the more common inorganic constituents of plant tissues. Plant Physiol., Vol. 19, No. 1.

LÜDERS, R. 1955. Über die Verteilung von Phosphorsäure und Schwermetallen auf Korn und Stroh des Petkuser Sommerroggens. Z. Pflanzenernähr. ung., Düng, Bodenkunde, B. 68 (113), H. L

MEARS, B. and R. HUSSEY. 1921. The use of Perchloric Acid as an aid to Digestion in the Kjeldahl Nitrogen Determination. J. Ind. a. Eng. Chem., Vol. 13, No. 11.

18. PEECH, K. and M. V. TRACEY. 1956. Moderne Methoden der Pflanzenanalyse. B. 1, Springer-Verlag., Berlin, Göttingen, Heidelberg, S. 468-502.

19. SMITH, F. 1934. Mixed Perchloric and Sulfuric Acids. Ind. and Engng Chem. Vol. 6, No. 3.

20. TOTH, J., A. L. PRINGE, A. WALLACE, and D. S. MIKKELSEN. 1948. Rapid quantitative determination of light mineral elements in plant tissue by a systematic procedure involving use of a flame photometer. Soil Sci. Vol. 66, No. 6.

21. FREAR, W., W. A. THOMAS, and H. EDMISTON. 1919. Notes on use of potassium permanganate in determining nitrogen by the Kjeldahl method. J. Assoc. Official agric., chemists, Vol. 3, No. 2.

22. WOLF, B. and V. ICHISKA. 1947. Rapid chemical soil and plant tests. Soil Sci., Vol. 64, No. 3.

METHODS OF ASSESSING SOIL ALGAE AS A COMPONENT OF THE MICROFLORA OF SOIL

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In microbiological soil investigations, all the complex of soil microorganisms must be taken into account, if possible. Until recently, microbiologists studied mainly bacteria, actinomyces and partly fungi. Attention is now being given more and more to soil protozoa and algae, which are distributed throughout the soil.

However, soil algae are still being studied separately from other soil microorganisms. Algae are almost exclusively studied by botanists-algologists and primarily from the point of view of systematization. Algologists rarely relate their data to microbiological soil investigations. Microbiologists, on the other hand, do not deal generally with soil algae because of the specificity of the methods of investigation. This is why methodological problems are so important, in particular the working out of such simple methods which would allow microbiologists-soil scientists to include the study of algae into their field of work.

In the last 25 years, comprehensive soil-algological studies have been conducted in the USSR. The species composition of algae in various soil groups has been studied, certain principles of the development of algae in cultivated soils have been clarified and the participation of algae in soil processes is being studied. Material on the number of algae in soils and the mass of organic substances produced by them is accumulating and ways of using soil algae in practice are being sought out.

The best methods of determining and assessing algae have been established in the course of investigations. These methods may be recommended for extensive use during soil-microbiological work. In evaluating and selecting the methods, consideration was given to the requirements that investigation conditions be as close as possible to the natural habitats of algae, that they be as simple as possible and appropriate for mass use.

We will not review all methods in this article, but only dwell on those which, judging by the experience gained during our investigations, best fulfill the foregoing requirements. We have in mind methods of determining and assessing algae in the soil, i.e., methods of determining the composition and amount of algae. Detailed physiological or morphological studies of individual species will probably require special methods, which are not being examined here.

Methods of determining soil algae are really specific and differ in many aspects from methods of study of other soil microorganisms. This specificity is determined by the following morphological and physiological characteristics of algae: 1) as autotrophic organisms they require light, water and mineral salts for growth in a culture; 2) their growth in cultures is comparatively slow, especially for spore-forming forms; 3) the large size of cells, not less than 3μ for individual cells and 1μ in width for filamentous forms, make the identification of species possible only from morphological indices; 4) multicellular colonial and filamentous forms are frequently found, many of which form a strong slime, which makes a uniform distribution of cells difficult during the preparation of a soil suspension.

Both qualitative and quantitative methods are used in the study of soil algae. In both cases soils samples are collected under sterilized conditions. Qualitative methods give the composition of species and the general characteristics of algal associations. These methods are represented primarily by various versions of the culture method, in which the soil under study is placed in a sterile nutrient medium, either liquid or agar. More simple aqueous media are usually used for the culture of algae; distilled water from a distilling glass apparatus is used; tap water often produces a deterioration of the growth of the culture.

There are many recipes for the preparation of mineral nutrient media for the culture of algae; the main recipes, as well as the techniques of growing a culture are described in the literature (3, 4, 5, 7, 18). The Bristol medium, as modified by Gollerbakh, is especially frequently used for determining soil bacteria. It consists of:

$NaNO_3$—0.25 g, KH_2PO_4—0.25 g, $MgSO_4$—0.15 g, $CaCl_2$—0.05 g, NaCl—g and traces of Fe_2Cl_6

to 1 liter of water. At the present time, media containing soil extract are being used more and more, such as the Danilov medium (750 ml water, 250 ml of extract from garden soil, 0.2 g of $Ca(NO_3)_2$ and 0.2 g of K_2HPO_4) and an extrac from the soil under study with NPK salts added t, which was first used by Bolyshev and ucharova (1) and then by Mel'nikova (16).

All media which contain readily available ieral salts have one essential disadvantage; y create conditions favorable mainly to idly propagating green algae, which depress development of other species. This is why ter results are obtained in many cases with ire extract from the soil studied. This ex- ct cannot be used for the investigation of soils ch are poor in nutrients, such as samples m deep horizons, or very acid soils. In our estigations this was true of sod-podzolic ls, chernozems, many solonetzes and other ls. The extract is prepared by shaking one t soil with four parts of water for five iutes and subsequent filtration through the ire soil thickness.

In comparing cultures grown in a pure soil ract and in the medium of Danilova the fol- ing differences were noted. More cells of en algae develop in the medium with the ieral salts and the cells are larger and ghter than in the soil extract. However, a ater variety of species appears, as a rule, pure soil extract (Table 1). In addition, an sual grading of samples of various origins urs in a mineral medium, while in the water ract the difference between samples stands more clearly.

Aqueous nutritional media are poured into -250 ml conical flasks in amounts of 60-100 After sterilization, a given sample (usually g), or a given volume of soil, is placed in flask. For qualitative analysis it is not essary to bring the soil to the air-dried state, to pulverize and sieve it. On the contrary, best results are obtained by using freshly- ected soil.

The problem of the time the soil can be stored not been fully solved yet. Many soil algae e proved to be very resistant to drying (29). lerbakh (3) showed by special experiments the storage of soil in the air-dried state for -2 years does not affect the correctness of ie determinations. However, the allowable iod of storage apparently varies for various s and various groups of algae. As Meyyer ed (15), many green algae among Conjugatae certain diatoms do not withstand drying; the same is true of Euglenoidina. This is why cultures should be grown within a few months after the collection of samples and not later than one year.

Algal cultures grow in light; for this purpose the natural light from windows exposed to the north or northeast is used, while artificial light is used in winter. When light is deficient, mold fungi develop in the culture instead of algae. However, even with additional light, the seasonal periodicity of the growth of algae manifests itself in the culture, as shown by Goryunova and Nasonova (9). This is why the best time for growing soil algae in the central belt of the USSR is from the end of February to the beginning of November.

The species of algae growing in a culture are determined with a microscope. There is a certain sequence in the appearance and disappearance of species in a culture (27) and this is why the necessity arises of repeatedly examining them, starting after three weeks and ending after 3-4 months.

The identification of algae up to the species from keys requires special training and can only be made properly by algologists. The variety of the algal flora of soil is evidenced by the fact that in the soils of the USSR about 900 species and forms of algae were discovered; among them the same number of species is represented by green algae, blue-green algae and diatoms; there is a lesser number of yellow-green algae and only a few species of Euglenoidina, golden and pyrophytic algae.

Thus, a full list of all species of algae is not necessary in mass microbiological soil investigations. It is sufficient to determine the predominant forms and identify them up to the genus. For this purpose a series of local keys can be used (6, 11, 13, 14, 20, 24).

A simplified qualitative method which can be used by any microbiologist is that of dish (soil) culture. This method is simple, as close to natural conditions as possible, ensures rapid growth and can thus be used for preliminary orientation (12, 25, 17, 23, 19). The soil studied is placed, possibly in an undisturbed state, in sterile Petri dishes and in a moist state (up to 80%-100% of moisture capacity) under light. The

Table 1

Number of species of algae in various nutrient media

Soil	No. of species identified	
	In a pure soil extract	In the Danilova medium
Sod-podzolic	28	22
Chernozem	17	15
Crusty solonetz		
a) In the crust	18	22
b) In the layer from 0-5cm	23	21
Takyr-like solonetz	14	9

Table 2

Number of species of algae in aqueous cultures and on growth glasses

Soil	Time of soil storage	Number of algae species			
		In a soil extract	In the Danilova medium	In growth glasses	Total
Sod-podzolic	2 month	26	—	27	23
Peat-bog	10 days	22	—	23	18
West Siberian chernozem	2 years	—	26	15	13
Dark-chestnut	5 months	—	27	26	19
Brown-desert-steppe	8 "	19	—	10	8
Deep solonetz	5 "	18	16	20	12
Deep solonetz	3 "	19	—	22	17
Meadow solonetz	2 years	—	23	12	8
Meadow solonetz	5 months	—	42	38	23

growth of algae, which rapidly appear at the soil surface and on the walls of the dish, is studied under the microscope.

A successful variation of the dish culture is that of "growth glasses," first used by Lund (31) for the culture of diatoms and then by Vaulina (2). Sterile glass covers are placed on the soil surface in a dish and the soil is moistened periodically. Lund and Vaulina used a mineral solution for moistening. Judging from our observations, sterile distilled water may be used as successfully. Algae, which predominate in the given soil, soon begin to grow rapidly on the glass. Already after 3-4 days the glass may be examined under the microscope and the final results can be observed after two weeks. This is why growth glasses allow rapid determination of the predominating soil algae associations and the relation between large systematic groups. The importance of this method to the investigation of algae may apparently be compared to the importance of "growth glasses" for the identification of the "active microflora" of soil by the method of Rybalkina and Kononenko (22).

We compared the growth of algae in aqueous cultures and in growth glasses. The percentage of correspondence, i.e., the number of species determined simultaneously in both cultures, differs for various cases and depends primarily on two factors: the composition of the algae, which is determined by the properties of the soil, and the time the soil samples were stored. The composition of the medium taken for the aqueous culture apparently also plays a role (Table 2).

The sooner after the collection of soil the cultures are grown, the closer are the results obtained in both types of culture. At the same time, the difference between aqueous and growth glass cultures is always due to the same systematic differences. Comparatively more green and yellow-green algae and many less diatoms, or sometimes no diatoms, develop in aqueous cultures. There are always more diatoms and blue-green algae of the Oscillatoriaceae family on growth glasses. For example, the species Oscillatoria, Phormidium, Microlens grow better on glass.

Thus, on growth glasses the following appear first: 1) very bulky forms, the buds of which touch the glass; 2) those which tend to grow at the surface of the soil (diatoms, blue-green algae in a slimy envelope, desmidiaceae, species of Hormidium, etc.); and 3) forms which are in an active state and which perish under prolonged drying and cannot be identified any more. In aqueous cultures, on the other hand, forms appear which are in the dormant state, preserved in the form of spores, in addition to those contained in the soil in the vegetative state.

In relation to this a question of principle arises as to how truly cultures reflect natural phenomena and whether it is possible to judge the state of the species in natural algal associations from data obtained by the culture method. Life conditions in aqueous cultures differ essentially from natural conditions. This is why aqueous cultures may give a wrong idea of the complex of dominating forms, even though they reflect well the general composition of algae living in soil. This is compensated for by dish cultures with growth glasses which primarily reflect bulky and active forms. In addition, the freshly-collected soil must be examined microscopically whenever possible, this is especially important in the presence of surface films and generally for soils which are rich in algae. Direct microscopic examination cannot replace the culture method, but it aids considerably in preliminary orientation.

Thus, when making algological soil investigations, classical aqueous cultures must be supplemented with soil cultures with growing glasses and, if possible, with microscopic examinations of freshly-collected soil.

Mass microbiological investigations may be limited to soil cultures with growth glasses, which can be grown by any microbiologists and which give an accurate idea of the bulky types of algae in a given soil.

Special attention should be paid to the identification of diatoms. Algologists solve this problem in a different way. They examine aqueous cultures and usually come to the conclusion that soil is poor in diatoms. Actually, diatoms are from always being identified in aqueous culs because they begin to grow very early, weeks after a culture is started, and then die dly, whereby even their shells often disap-, which according to Goryunova (8) may within several hours. If the examination of lture is delayed, the impression may be ed that there are no diatoms in the sample. r authors separate diatoms from the soil r study by elutriation. Since the determina- of diatoms is made from ignited samples, it udes not only live cells, but also empty shells ained in the soil. As a result, the list of tified species includes forms which are not rent to soil, for instance, empty shells of ous forms which were accidentally introd into the soil by water or wind.

he only correct approach to the problem of identification of soil diatoms is their deteration on growth glasses by the method of d (31). Our data show that this method is icable to all soils, it reflects well the live cies contained in the soil and at the same shows the relative importance of diatoms e life of various soils.

ualitative methods are insufficient for ing the problem of the role of algae in soil. rder to judge the scale of activity of algae, must know their number and the number of s in various soil layers. Quantiative meth- have a decisive importance for microgical soil investigations, but they have not worked out yet, and to this day quantitative stigations of soil algae are rarely made.

uantitative methods are divided into culture direct methods. Because of the effective- of the culture method in determining the position of algal associations, attempts made to use it for the determination of the ber of algae (30, 32). However, the methods unting from cultures, which involve succes- dilution of the soil suspension and inoculat- t in the nutrient medium, have a number of tcomings and are not widely adopted. They used only by Rikhter and Orlova (21) and va (19) in the USSR. The shortcomings of re counting methods are due to the uneven th of individual species and the impossibility taining a uniform distribution of cells in the ension. This causes inaccuracies in the t. In addition, these methods are cumber- e and, if many determinations are made, ire inoculation and examination of all the els in which the cultures are grown.

e find direct methods of counting more conent and promising. In the last 10 years we used the method of Vinogradskiy in a simed and modified form for the direct inigation of algae. This method can be used ther than freshly-collected samples; if it is ssible to analyze a sample immediately it has been collected, a 1-g (or 1 cm^3 of sample of air-dried soil is fixed with 4% alin and can be examined later. The soil xed with formalin as soon as it is air-dry, use prolonged drying may cause the deforon of many algal cells.

he simplified method of counting algae used s (26) consists in the following. A 1-g samf soil is shaken in 4 ml of water (or formalin, if it has been fixed) for two minutes, left to settle for half a minute and poured into a centrifuge test tube. An additional 3 ml of water is poured twice into the remaining sediment and after shaking for a minute and settling for half a minute it is poured into the same tube. The suspension obtained is then poured in three centrifuge test tubes and centrifuged for one minute at 500 rotations, or for two minutes in a manual centrifuge. All the suspensions remaining after centrifuging and sediment 1 (heaviest particles which settle on sedimentation) are practically deprived of algae and are not taken into account. Each of the remaining sediments is brought up to a certain volume with distilled water, depending on the density of the suspension (usually 10-20 ml), and after thorough shaking a drop of the suspension is placed on a counting plate or a slide and quickly covered with a cover glass. The volume of the drop is determined from the number of drops in a milliliter. The drop is examined either in its entirety or in part, for instance, every second or fifth longitudinal line, equal in width to the diameter of the field of vision. The number of algae in the preparation is recorded individually according to systematic groups. In the presence of multicellular forms, the number of varieties and the number of cells are noted. The number of algae in the entire suspension is determined by means of conversion and the sum of all three preparations gives the number in 1 g of soil.

Comparison with culture methods showed a number of advantages of the direct method: 1) it is more accurate and gives a larger number of cells. For instance, in the simultaneous investigation of one sample by the Rikhter and Orlova method (21) and the method of direct counting, the following values were obtained: 10,000 cells of green algae exclusively in 1 g of soil were determined by the culture method, while direct microscopic examination of this sample gave 176,000 cells in 1 g of soil, including 51,800 cells of diatoms, 7200 cells of blue-green algae and 11,700 cells of green algae. 2) It is more rapid if one takes into account all the operations involved in the preparation of a medium and the examination of all vessels. 3) It not only allows counting, but also observation of the state of algae under soil conditions.

The direct method of counting requires a certain experience in order to be able to differentiate algal cells from other particles, but may be used by any microbiologist. The method also has its disadvantages: 1) possibility of an error due to the failure of counting certain individual cells; 2) the difficulty of uniformly distributing the cells of filaments and colonies of algae; and 3) the amount of work involved (3-5 hours are required to process one sample, depending on the soil texture). The use of fluorescent microscopy in the work of Tchan (33) is promising for the perfection of this method. The method of Tchan differs from our method in that the soil suspension is examined in a fluorescent microscope and all algal cells become visible at once as a result of the fluorescence of chlorophyll. Counting is effected more rapidly, however, it is impossible here to distinguish between systematic groups of algae. In addition, difficulties arise in the fixation of the material.

For the quantitative assessment of algae, Gromov (10) has recently used a method of growing cultures of fine earths and noted its simplicity and accuracy as compared to the Bristol method. We compared the method used by Gromov with the method of direct counting and came to the following conclusions. The culture of fine earths in 2% aqueous agar, or even better on a soil extract with agar, is a successful modification of the qualitative method, allowing rapid determination of the bulky forms of algae. In this respect it is similar to the growth glass method. Diatoms, and green and blue-green algae grow well on agar, including spore-formers (for instance, species of Anabaena, Amorphonostoc, Stratonostoc), which grow slowly on glass. From the first days of growth, the algae, including diatoms, filaments of Oscillatoria, Phormidium, Microcoleus, Chlamydomonas cells, and the zoospores of green and yellow-green algae, begin to move actively at the surface of agar and emerge from the water film surrounding the little clumps of soil. As a result secondary colonies soon appear which are not connected to the small clumps of soil and the boundaries between primary and secondary colonies disappear. Filamentous forms do not form a solid network in which primary and secondary colonies cannot be distinguished. Such results were obtained with the cultures of three different soils: sod-podzolic, peat-bog and crusty solonetz. Samples of 10-20 mg were taken. Five days after the cultures were started, colonies could be counted, but this count gave much lower values than those obtained by direct counting. For instance, 9300 individuals (not counting cells) were found in the solonetz, while direct counting showed 568,000 individuals; 5500 individuals were counted in sod-podzolic soil on agar, while direct counting gave 123,300. At a later time counting was made impossible by the movement of the algae. We must note another factor: that samples in Petri dishes are examined under a microscope at low magnification and this takes a lot of time. The examination of half a dish takes 1.5-2 hours. If one takes into account that counting is performed twice and much time is spent on growing the culture, it turns out that the culture method does not save time as compared to the direct method and is much less accurate.

Thus, in spite of a number of disadvantages, such as the work involved, the direct method of counting is the most convenient. We must search for a simplification of this method which would accelerate work without decreasing accuracy.

The direct method of quantitative assessment was widely used by us (25, 27, 28) for the solution of problems on the number of algae in various soils, their distribution in the soil profile, their seasonal dynamics, the influence of agricultural practices and fertilizers on the development of algae in soils and the accumulation of algae in the rhizosphere of various plants.

In certain cases we determined the biomass of algae after determining the number of their cells. All mass determinations were, of course, made on the basis of the mean size of cells and are very approximate. But there is no other way yet for determining the mass of algae scattered in the soil. In addition, even approximate values make it possible to compare the mas of algae in various soils. For instance, the biomass of algae in sod-podzolic soils varies from 40-300 kg/ha, that in podzolic soils, from 7-20 kg/ha, in peat-bog soils, from 20-80 kg/ha, in meadow soils, up to 500 kg/ha, etc.

The accuracy of the quantitative assessment greatly depends on the manner in which the soil samples are taken. Soil taken for the counting of algae should correctly reflect the average state of the site under investigation. An average sample is best used for quantitative determinations, which is obtained by mixing several initial samples, as it is done in normal microbiological soil investigations. In order to characterize an area up to 100 m² it is sufficient to take 4-5 initial samples, while for an area exceeding 100 m² samples must be taken from 8-10 spots. Algae are very unevenly distributed along the soil profile, developing primarily in the upper layers. This is why in determining the number of algae in a given soil, the layer to which a given number of algae belong must be accurately noted. All samples for quantitative determinations of algae are usually taken from the 0-10 cm layer. A special case of quantitative determination involves the counting of algae in films and crusts which form at the soil surface under favorable moisture conditions. Cells in surface films are counted not on weight basis, but on area (1 cm²) basis. During the collection of samples for counting, surface films must be taken individually by fixing 1 cm² of the film. The samples are prepared for counting in the usual manner, but because of the abundance of algae and the difficulty of separating the algal tomentum, the suspension must be shaken for a long time and the counts repeated. Qualitative and quantitative methods of investigating algae supplement each other and by combining both methods the most accurate results are obtained.

Data on the composition and number of algae are of great importance to the characterization of microbiological processes in soils. This is why it is desirable to include the assessment of soil algae into the program of microbiological soil investigations.

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BIBLIOGRAPHY

1. BOLYSHEV, N.N. and YE.A. MANUCHAROVA. 1946. Vegetation of takyrs. Vestnik Moskovskogo Universiteta. No. 3-4.

2. VAULINA, E.N. 1958. Major features of the algal flora of certain soils of Belorussia. Vestsi Akad. Nauk BSSR. No. 1.

3. GOLLERBAKH, M.M. 1936. Problem of the composition and distribution of algae in soils. Trudy Botanicheskogo instituta Akad. Nauk SSSR, Ser. II, No. 3.

4. GOLLERBAKH, M.M. 1951. Algae, their structure, life and importance. Moscow.

5. GOLLERBAKH, M.M. and V.I. POLYANSKIY. 1951. Fresh-water algae and their study. Moscow.

GOLLERBAKH, M. M., YE. K. KOSINSKAYA, and V. I. POLYANSKIY. 1953. Blue-green algae. Opredelitel' presnovodnykh vodorosley SSSR. No. 2.

GORYUNOVA, S. V. 1948. Cultivation of algae under laboratory conditions. Mikrobiologiya. No. 5.

GORYUNOVA, S. V. 1958. Characteristics of the process of autolysis of diatoms. Trudy Instituta microbiologii Akad. Nauk SSSR. Vol. 5.

GORYUNOVA, S. V. and M. V. NASONOVA. 1955. Phenomenon of the seasonal change in the growth and development of unicellular green algae. Mikrobiologiya. No. 2.

GROMOV, S. V. 1956. Observations of algae of primitive soils of certain northern regions of the USSR. Uchenyye zapiski Leningradskogo Universiteta. 216.

ZABELINA, M. M., I. A. KISELEV, A. I. PROSHKINA-LAVRENKO, and V. S. SHESHUKOVA. 1951. Diatoms. Opredelitel' presnovodnykh vodorosely SSSR. No. 4.

ZAUER, L. M. 1956. Contribution to the knowledge of algae of plant associations of the Leningrad Region. Trudy Botanicheskogo Instituta Akad. Nauk SSSR. Ser. II, No. 10.

KORSHIKOV, O. A. 1938. Volvocineae. Viznachn. prisnov. vodorostey URSR. IV. Kiev.

KORSHIKOV, O. A. 1953. A subclass of Protococcineae. Viznachnik prisnov. vodorostey URSR. V. Kiev.

MEYYER, K. I. 1937. Algae of bog soils in the valley of the Yakhroma River. Trudy Botanicheskogo Sada Moskovskogo Universiteta. No. 1.

MEL'NIKOVA, V. V. 1955. Algal flora of chernozem soils in southern Tadzhikistan. Izvestiya otdeleniya yestestvennykh nauk Akad. Nauk Tadzhikskoy SSSR. No. 9.

NOVICHKOVA, L. N. 1955. Associations of lower plants of takyrs in the piedmont valley of Kopet-Dag. Author's summary of her dissertation. Leningrad.

NOVOGRUDSKIY, D. M. 1956. Soil microbiology. Alma-Ata.

POPOVA, T. G. 1957. Soil algae of old abandoned land under reclamation in Western Siberia. Trudy Biologicheskogo Instituta Zapadno-Sibirskogo filiala Akad. Nauk SSSR. No. 3.

POPOVA, T. G. 1935. Euglenoidina. Opredelitel' presnovodnykh vodorosley SSSR. No. 7.

21. RIKHTER, A. A. and K. I. ORLOVA. 1928. Experimental assessment of algal flora in the soils of the city of Saratov. Nauchno-agronomicheskiy zhurnal. No. 5-6.

22. RYBALKINA, A. V. and YE. V. KONONENKO. 1956. Active microflora of soils. Pochvovedeniye, No. 3.

23. SDOBNIKOVA, N. V. 1956. Soil algae of takyrs in the northern part of the Turan lowland. Author's summary of her dissertation. Leningrad.

24. TOPACHEVS'KIY, O. V. and M. F. MAKAREVICH. 1955. Short list of freshwater algae of the Ukrainian SSR. Kiev.

25. SHTINA, E. A. 1955. Algae of sod-podzolic soils and their role in soil processes. Author's summary of his dissertation. Moscow.

26. SHTINA, E. A. 1956. Method of quantitatively assessing soil algae. Botanicheskiy zhurnal. No. 9.

27. SHTINA, E. A. 1959. Algae of sod-podzolic soils of the Kirov Region. Trudy Botanicheskogo instituta Akad. Nauk SSSR. Ser. II. No. 12.

28. SHTINA, E. A. 1959. Algal associations of the main soil groups of the USSR and their diagnostic importance. Botanicheskiy zhurnal. No. 8.

29. BRISTOL, B. M. 1919. The relation of vitality by algae from old store soils. New Phytologist. 18(3-4).

30. BRISTOL-ROACH, B. M. 1927. Kulturmethoden zur Bestimmungen der Zahl der Algen im Boden. In: Wachsman. Methoden der microbiologischen Bodenforschung. Berlin.

31. LUND, J. W. G. 1945. Observation on soil algae. I. The ecology, size and taxonomy of British soil diatoms. New Phytologist. 44(2).

32. PETERSEN, J. BOYE. 1935. Studies on the biology and taxonomy of soil algae. Dansk bot. arkiv. No. 8.

33. TCHAN, J. 1953. Study of soil algae. I. Fluorescence microscopy for the study of soil algae. Proc. Linnean Soc. New South Wales. 77(5-6).

RESULTS OF LEACHING FINE-TEXTURED SOILS, SALINIZED WITH SODIUM SULFATE

A.K. AKHUNDOV, K.G. TEYMUROV

There is no reason to doubt the experimental setup and the results of observations made by A.A. Kizilovoy on the mobility of Na^+ and $SO_4^=$ during winter leaching.[1] But her conclusions that "...the investigations made confirm the effectiveness and necessity of the winter leaching of solonchak-like soils, including solonchaks with the sulfate-magnesium-sodium type of salinization" gives us, who work in the zone of of sulfate-sodium (mirabilite) salinization in the Kura-Araks lowland of the Azerbaydzhan SSR, cause for comment on this subject.

As A.A. Kizilova mentions in her work, the solubility of sodium sulfate depends on the temperature of the water and greatly decreases with decreasing temperature. Under the same temperature the solubility of sodium sulfate varies greatly depending on its form of crystallization (Table 1).

The work conducted on the leaching of fine-textured soils at the Shirvan experimental drainage area of the Azerbaydzhan Scientific Research Institute of Hydraulic Engineering and Melioration (AzNIIGIM), which are salinized to various degrees with sodium sulfate, clearly showed that sodium sulfate precipitates in the form of mirabilite during winter leaching when air and water temperatures drop sharply.

The Shirvan steppe represents the northern part of the Kura-Araks lowland in the Azerbaydzhan SSR. The area occupied by saline soil is more than 60% of the total land area. In order to study and obtain parameters for drainage, the Azerbaydzhan Scientific Research Institute of Hydraulic Engineering and Melioration began constructing an experimental drainage area of 1000 ha in the Shirvan steppe in 1955. Geomorphologically, the experimental drainage area is located at the periphery of the alluvial fan of the Geogchay River. The 5-m thick layer of soil consists primarily of clays and fine clay loams. Even the areas next to the drainage ditches, which usually consist of soils of a coarser texture, are composed of clays and fine clay loams from a depth of 40-60 cm down. It was established that the ground water over most of the experimental drainage area is located deeper than 3 m in autumn and summer. It was also established on the basis of the analysis of 200 samples of ground water that it is mainly sulfate and highly mineralized. The salt content in the ground water varies from 10-75 g/l and more as solid residue. The amount of $SO_4^=$ and Na^+ is considerable: 32-39 g/l (667-811 meq) of $SO_4^=$ and 10-13 g/l (470-578 meq) of Na^+.

The soils of the area are salinized to various degrees. The amount of solid residue in water extracts from soil sometimes reaches 3%-5%, the amount of $SO_4^=$ being 0.69%-2.31% (14.5-48.1 meq) and that of Na^+, 0.31%-0.98% (13.5-42.8 meq).

Beginning in the fall of 1957 saline soils in the area were being leached against the background of a deep horizontal drainage system. Without going into details of the investigations, we can indicate in general outlines that during the leaching of an area of 70 ha with weakly- and moderately-saline soils (solid residue of not more than 1%-1.5%), where mineralized ground water (10-25 g/l) is located at a shallow depth (1.5-2.5 m), sulfates did not precipitate in the form of mirabilite in the mineralized solution (in the leachate) during mild winters.

During experimental leachings in the fall and winter of 1958-1959, when in the Kura-Araks lowland air temperatures dropped to -3°C and water temperature also dropped during the period from December 1, 1958 to March 3, 1959 (there was a snow cover for 10 days), different results were obtained.

During the leaching of sulfate solonchaks in an area of 40 ha, where highly-mineralized ground water (50-75 g/l) was initially located at a great depth (4-5 m and more), mirabilite crystals were found to precipitate in great quantities in cracks in the slope of drainage ditches, at the surface of water in the ditches and in places where mineralized ground water appeared on the bottom of drainage ditches. One of the accumulations of crystals collected by us from the bottom of drainage ditch No. 8 on February 3, 1959, occupied an area of 80x80 cm at a time when the mean air temperature was +3° C and + 4°C. The height of the accumulation in its central part was 20 cm and its weight was 39 kg (the photograph represents its frontal cross-section). Mirabilite

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[1] Pochvovedeniye. 1959. No. 5.

Table 1

Solubility at room temperature of sodium sulfate crystal hydrates[a]

Formula	t°C	Grams of water-free substance in 100 g solution
$Na_2SO_4 \cdot 10H_2O$	20	16,1
$Na_2SO_4 \cdot 7H_2O$	20	30,9
Na_2SO_4 rhombohedral	19	34,7

[a] "Chemiker-Kalender." Vol. II, 1932.

Note: Comma represents decimal point.

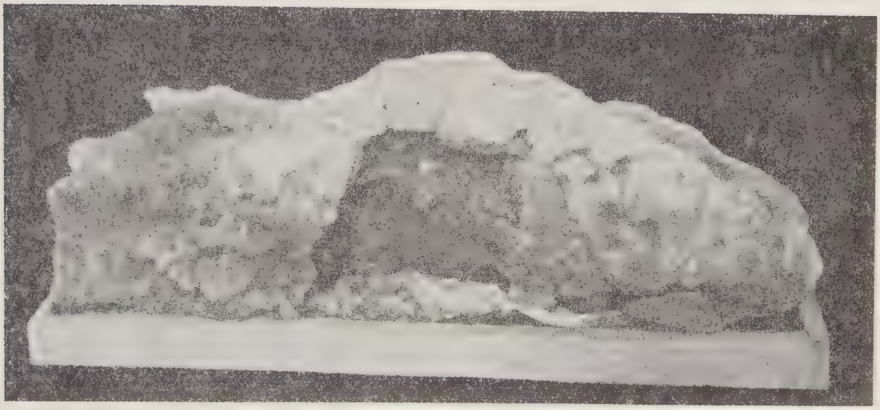

Fig. 1. - Accumulation of mirabilite crystals.

cipitates in this form around grifonchikov, , subaquatic "fountains" of ground water at bottom of drainage ditches under the pres- e of leaching water filtering into the soil.

he observations made by us in the Shirvan pe give us reason to conclude that the effect eaching is greatly reduced under low air and er temperatures, because of the precipitation nirabilite from the soil solution during the nage of highly saline soils and solonchaks n soil and water salinization is of the sodium ate type. A very important practical con- ion may be drawn from this: that when nization is of the sulfate type (mirabilite), soil and soil material are highly saline (3%-5% solid residue) and ground water is initially highly mineralized (50-75 g/l and more),[2] leaching must be done in spring and summer on the background of rice plantings.

The conclusions of A. A. Kizilova are true only for the soils she investigated and are of no general significance.

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[2] When supplying leaching water at a rate of 3520 m^3/ha to an 11 ha area symmetrically distributed between drains 7, 8, 9 (E = 200 m), drainage runoff formed in 3-m deep drainage ditches within 20 days.

CONSTANT-ELECTRODE DEVICE FOR THE STUDY OF THE DYNAMICS OF OXIDATION-REDUCTION CONDITIONS IN SOILS

P. M. NOVIKOV

The determination of the oxidation-reduction potential (ORP) of soils is widely used. Even single measurements of the ORP in the genetic horizons in a freshly-cut trench often serve as interesting indicators of oxidation-reduction conditions. The study of the dynamics of ORP under permanent conditions gives very valuable information on the dynamics of the moisture and air regime of soil, as well as the direction and intensity of changes occuring in the soil profile, and allows deeper insight into individual aspects of the complex process of soil formation.

For permanent field investigations of the dynamics of ORP[1] it is recommended that electrodes be vertically installed in the soil for the duration of observation by means of Tamm's auger. This method is simple and rapid, however it has the following shortcomings: shallow depth for the insertion of the electrodes and the possible disturbance of the water and air regime of the soil at the electrodes.

In this article we wish to describe our experience with a constant-electrode device, which does not have the foregoing disadvantages. A 40-cm deep horizontal cut is made in the wall of a freshly-dug trench (immediately a description of it is made and the samples are taken) with a special metal pin (Fig. 1a). A platinum electrode of the usual type is inserted into the cut to full depth. The wire from the electrode is brought out to the soil surface (its length at the surface must be about 1.5 m). The presence of a contact between the platinum electrode and the soil is checked with a potentiometer. If there is no contact, the electrode is carefully pressed into the wall of the cut until contact is made. The contact between a calomel electrode and the soil is established by means of an agar-agar bridge. In order to do this a wide and short test tube (about 2 cm wide and 7-8 cm long) with saturated KCl solution is buried halfway in the ground, the calomel electrode and one end of the agar-agar bridge are inserted in the tube, while the other end of the bridge is lightly pressed into the soil near the tube.

After all the electrodes are placed in the wall of the trench, the contact between the platinum electrode and the soil is checked again and the preliminary ORP is recorded.

After the electrodes are placed and checked, the trench is slowly backfilled with soil layer by

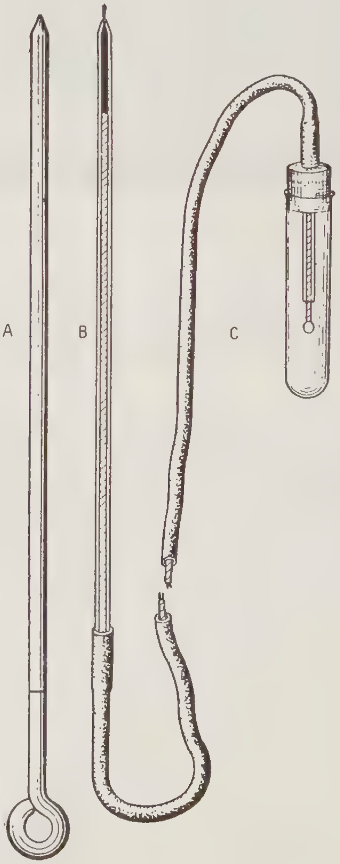

Fig. 1. - Assembly of constant electrode. A - pin; B - platinum electrode; C - external end of lead.

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[1] Serdobol'skiy, I. P. 1954. Methods of determining the pH and the oxidation-reduction potential during agrochemical investigations. Agrochemical methods of soil investigations. Instructions for field and laboratory investigations. Moscow.

yer, tamping each layer and taking care that
e soil be in the same position as it was
iginally. After backfilling, the ORP is
easured.

The electrodes are prepared beforehand. The
tinum is fused into a thick-walled glass tube
h a conical end. Pure mercury is poured in-
the tube (the mercury column must be 3-4 cm
gh) to make a contact between the platinum and
e wire. The uninsulated and cleaned end of
e wire (3-4 cm long) is inserted into the mer-
ry to the end of the glass tube (to the free end
platinum). The wire should be of such thick-
ss that it is easily inserted into the glass
be. It is recommended that the wire be
ckened with a fine silk or glass thread above
e bare portion so that the mercury cannot spill
t no matter in what position the electrode is
ee Fig. 1b). The length of the glass tube for
e electrode is 40 cm and its diameter is 0.5 mm less than the diameter of the pin with which the horizontal cut for the insertion of the electrode is made. Such a difference between the diameters of the electrode and the pin assures the comparatively easy insertion of the electrode into the cut to its full depth. The wedge made by the pin in the soil rapidly closes over the tube of the electrode and fully cuts the flow of outside air toward the platinum end of the electrode (we worked with a pin 9 mm in diameter and a glass tube 8.5 mm in diameter). The deep (40 cm) insertion of the electrode into the wall of the trench hinders the exchange of soil air with outside air during the placement of the electrodes.

The placement of constant electrodes into the wall of the trench, as described previously, does not disturb the natural moisture and air regime of the soil and allows study of the dynamics of oxidation-reduction conditions to considerable depths in the soil profile (up to 4 m and more).

CHRONICLE

GENERAL RESULTS AND FUTURE OUTLOOK OF WORK OF THE V.V. DOKUCHAYEV SOIL INSTITUTE, ACADEMY OF SCIENCES, USSR[1]

I. V. TYURIN

The scientific work of the Soil Institute of the Academy of Sciences of the USSR is directed mainly toward a thorough study of the soils of the USSR with a view toward their more rational utilization in the national economy and improvement of their productivity.

The scientific research work of the Institute is directed toward:

I. The study and qualitative assessment of land resources of the USSR as a basis for their rational utilization in the national economy (genesis, classification and mapping of the soils of the USSR, agricultural soil zonation, and soil site quality).

II. The development of scientific principles for increasing the productivity of soils (scientific basis of methods for creating soil conditions for high crop yield).

III. The control of soil erosion and other unfavorable development.

IV. The development and perfection of methods of soil research in conformity with the progress in basic and related sciences.

In relation to the work conducted in the foregoing fields and the utilization of the results obtained, the Institute conducts experimental and theoretical studies, as well as generalized work with the view toward the further development of soil science. Taking into account the close connection between soil science and related branches of biological and geological-geographical sciences, as well as between certain problems of soil science and chemistry and physics, the Institute always tries, when possible, to conduct its investigations together with other institutes of the Academy of Sciences (by participating in complex expeditions and by setting up mixed brigades).[2]

I. Study and Qualitative Assessment of Land Resources of the USSR

This section includes work on the classification, genesis, and mapping of the soils of the USSR, agricultural soil zonation, quantitative and qualitative assessment of the land resources of the USSR, and soil site quality.

The most important work of this section is the compilation and publication of an official soil map of the Soviet Union on a scale of 1: 1,000,000. This work is done at the order of the Council of Ministers of the USSR by the Soil Institute in collaboration with many soil scientists of numerous local institutions of the USSR. It can serve as an example of the most effective creative form of coordination of the work of the Institute and other institutions under the Academy of Sciences of the USSR and Union Republics, as well as under other departments (Ministry of Agriculture, Ministry of Higher Education).

Compilation of this official soil map is organically related to the development and perfection of the general classification and systematization of the soils of the USSR, which is conducted by the staff members of the Institute and is approved at the plenary meetings of the Special Intradepartmental Commission on Soil Systematization and Nomenclature at the Soil Institute.

The compilation of the official soil map and the development of the general classification of the soils of the USSR are an important scientific generalization of soil geography and soil systematization. This work is also important from the organizational point of view for all regional investigations on soil cartography conducted in the USSR, including studies on the compilation of detailed soil maps for kolkhozes and sovkhozes. The general system of soil classification, developed by the Soil Institute, is used in all these studies. It is well known not only to soil specialists, but also to the agronomists of kolkhozes and sovkhozes. This fact was noted and acknowledged as a major practical achievement of the Soil Institute in a report published by a group of American soil scientists and soil-improvement specialists which visited the USSR in 1958.

The compilation and publication of the official

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[1] Reported at the extended meeting of the Bureau of the OBN (Department of Biological Sciences) on October 6, 1959.

[2] The results of studies on soil geography and experiments conducted by the Soil Institute were also reported at the general meeting of the Department of Biological Sciences in the Spring of 1959. The report was published in Izvestiya Akademii Nauk SSSR. Seriya biologicheskaya, No. 4, 1959.

il map of the USSR is related to the general
rk on soil cartography (for instance, com-
ation of an educational soil map of the USSR
d neighboring countries on a scale of 1:4,000,
0, which was awarded a gold medal at the
ernational Exposition in Bruxelles in 1958);
expeditionary studies on soil geography in
rious regions of the Soviet Union, especially
its northern and eastern regions; to work on
ricultural soil zonation and assessment of
d resources and their utilization. In the
ter work, the Institute keeps close contact
h the State Planning Commission of the USSR
d with the Ministry of Agriculture.

In addition to work on the soil geography of
USSR, the staff members of the Institute
nder scientific and methodological assistance
the conduct of joint research in people's
mocracies (Chinese People's Republic, Al-
nia, Bulgaria, Romania, Vietnam) and also
Burma and Egypt. The work of the Institute
the Chinese People's Republic has an es-
cially large scope.

At present, the Institute supervises the com-
ation of an International soil map of Europe.
connection with this, the Institute organized
International working conference in June,
59, at which the legend for the soil map of
stern Europe was discussed. Preliminary
rk is also being conducted for the compila-
n of an International soil map of Asia. Both
work on the soil map of Europe and on that
Asia are being conducted in preparation for
International Congress of Soil Science to be
d in the USA in 1960, and will serve as an
mple of coordination and collaboration on an
ernational scale.

An important positive result of this work is
establishment of business and friendly re-
ions with foreign scientists and scientific
titutions, and the mutual exchange and en-
hment of ideas and methods.

An important collective work carried out by
Institute with the participation of staff mem-
s of other institutions was the publication of
tructions on soil surveying.

An important role in the solution of the
blem of the further development of Soviet
riculture will be played by detailed soil
dies and the compilation of large-scale maps
kolkhozes and sovkhozes, which will give the
st complete and diversified qualitative and
ntitative characterization of land reserves.
king into account the considerable expansion
his work in the near future, the Soil Insti-
e has been engaged since 1956 in scientific
methodological studies on large-scale map-
g and has established a special laboratory
this purpose. This laboratory (headed by
A. Liverovskiy) has worked out a method
using aerial photographs for detailed soil
pping and methods of interpreting aerial
tographs for various zones. The laboratory
solved a number of individual methodologi-
problems related to the compilation of de-
ed soil maps (most appropriate scales for
ailed maps and cartograms, the relation-
between the contours of both, etc.).

One group of staff members of the Institute (under the leadership of S. S. Sobolev) has worked out a plan for a comparative evaluation scale for soils of the major natural and economic zones of the USSR, using the legend of the official soil map of the Soviet Union, which made it possible to bring all materials for various zones and regions to a single site quality scale. To date, the Institute has worked out methodological instructions for developing site quality scales for individual oblast's, or natural-economic regions. These instructions have been approved by the Ministry of Agriculture and now serve as a basis for work in the field. To coordinate the foregoing work and allow an exchange of experience, the Institute, together with the All-Union Academy of Agricultural Sciences im. V.I. Lenin and the Ministry of Agriculture, called a special conference in December, 1959.

II. Development of Scientific Principles for Increasing Soil Productivity

The productivity of soil is increased by using various methods and measures which can be classified into four groups: 1) chemical; 2) physical; 3) meliorative; and 4) biological. The work of the Institute on the scientific basis for methods of increasing the productivity of soils is related to all the listed groups, which are studied both individually for each group and in relation to each other.

The work of the Institute proved the necessity and the high effectiveness of differentiating the fertilizers used according to the chemical properties of soils.

Important results were obtained from studies on the use of radioactive isotopes, in particular for determining the total available phosphates in soils and the magnitude of the coefficient of utilization by plants of applied phosphates. This work made it necessary to reconsider radically the existing concepts on the phosphate regime of various soils of the Union. It was determined that it is possible to sharply decrease the amount of phosphate on soils "overfertilized with phosphorus" in cotton-growing areas, use this phosphate to extend the area of fertilized soils, and thus increase the yield of cotton and other crops.

Chemical investigations with the stable nitrogen isotope revealed the high nitrogen losses (10%-30% of the applied quantity) when using nitrogen fertilizers. The established facts of "phosphorus overfertilization" and nitrogen loss of soils require re-examination of the ratio between nitrogen and phosphorus in the general manufacture of fertilizers and an increase of nitrogen fertilizers.

Basically new principles of the utilization of nutrients by plant roots in salinized soil horizons were established, and the practical impossibility of plants to assimilate nutrients from soil layers with a moisture content corresponding to their wilting content was determined.

Studies on the natural radioactivity of plowed soils in the valleys of the European USSR showed that radioactivity was determined by the presence of K_{40}, and, to a lesser degree, by uranium and thorium. Investigations on the influence of Sr_{89} and Sr_{90} emissions on the growth and development of agricultural plants showed that it was possible to regulate the intake of Sr_{89} and Sr_{90} by plants by using potassium and other fertilizers.

The agricultural laboratory compiled and published methodological instructions on the use of tagged atoms in chemical investigations; prepared the third edition of the instructions for agricultural investigations; and worked out a method of diagnosing the need of plants for fertilizers by analysis of plant sap.

To date, work is being conducted on the "chemical characterization of soils in the USSR" with the collaboration of staff members of various peripheral organizations of the Academies of Sciences of Union Republics, branches of the Academy of Sciences, educational organizations and scientific research institutes of the Ministry of Agriculture and the All-Union Academy of Agricultural Sciences im. V.I. Lenin.

The work of the agricultural laboratory is closely connected with the experimental work conducted by the laboratory of soil chemistry (under the leadership of V.A. Chernov) on the problems of the principles of the distribution and forms of certain microelements in soil and the nature of the acidity of sod-podzolic soils. A series of scientific articles has been published, which are devoted to the development and description of methods of determining certain microelements and include new data on the relation between the adsorption of hydrogen, aluminum, and magnesium in clay minerals. A staff member of the laboratory, D.N. Ivanov, designed an original flame photometer, which is now being mass-produced.

Investigations on physical methods of increasing the productivity of soils were conducted by the soil physics and technology laboratory, while these methods were also studied by other laboratories, such as soil biology, soil physics, and chemistry, and soil hydrology laboratories, in conjunction with meliorative measures.

The soil physics and technology laboratory (under the supervision of N.A. Kachinskiy) studied the characteristics of the physical and technological properties of various soils and methods of investigating the regime of physical and physical-mechanical processes in soils. Among the achievements of the laboratory are: the determination of the concepts on the physical and mechanical properties of soil, necessary for a genetic and productivity characterization of soils; the elaboration and, partly, the reintroduction of the concepts of water capacity, differential porosity, hardness, stickiness, and the coefficient of internal and external friction; the study of the physical-mechanical and thermal properties of soil along its profile; the development of a new method of determining the specific resistance of soils during plowing according to the physical-mechanical characteristics of soil, which considerably facilitates the construction of cartograms of the specific resistance of soils during tillage, and the design of a number of instruments in conjunction with it.

The possibility of increasing the upper limit of soil moisture, as an indicator of the ripeness of the soil with plowing rate, is worth mentioning again. The paper given on this subject by P.U. Bakhtin at the conference of the GDR (German Democratic Republic) drew great notice and lead to lively discussion.

The soil biology laboratory of the Institute (headed by I.V. Tyurin) made experimental investigations on the study of various methods of single deep tillage of sod podzolic clay loam soils. The investigations were made in field and small-plot tests during a period of 5-6 years and were accompanied by evaluation of yield and the development of plant root systems, and by studies of the water and nutrient regimes, and of the composition and dynamics of microflora. The results obtained led to the following conclusions:

1) deepening of the plowed layer (to more than 20-22 cm) by additional plowing and loosening of the podzolic A_2 horizon does not give positive results;

2) a more effective method is that of a single meliorative plowing to a depth of 40-45 cm, whereby the existing plowed layer remains at the surface in almost its entirety and only 25%-30% of the material from the illuvial-podzolic A_2B horizon is added to it. This is achieved by means of a special plow (modified trenching plow). When plowing in this manner, the hydrological and physical properties of soils and the water available to plants are increased for a prolonged period (not less than 5 years, the biogenic character of the soil is increased to a depth of 40 cm, and, as a result of all this, yield is increased by 17.4 centners/ha in conventional grain units in 5 years, which amounts to 18% of the mean yield for normal plowing to a depth of 20-22 cm. Increasing the depth of a single plowing to 60 cm using the trench method was not satisfactory.

The papers presented by us at the International conference on soil tillage, organized by the Agricultural and Plant Growing Institute at Müncheberg (German Democratic Republic), on the results of comparative studies of methods of deep plowing were highly appreciated, and the results found confirmation in the work of this Institute on similar meliorative plowing on the coarse-textured (sandy loam and coarse clay loam) soils, characteristic of the eastern regions of the GDR, where crops often suffer from summer droughts, as in the Moscow region.

The problems of the physics and technology of soil, especially from the point of view of their productivity, are always closely related to problems of soil hydrology, i.e., hydrological and physical properties of soils, the dynamics and regime of soil moisture, and problems of their regulation to secure moisture for plants. This aspect of the work is given special attention by the Institute, which, by the way, was reflected in the organization of a special laboratory of soil hydrology established in 1951 (head, A.A. Rode). This laboratory studies the types

moisture regime in the soils of various
nes, and successfully develops problems re-
ed to the utilization and conservation of mois-
e in the soils of arid regions. A large place
devoted by the laboratory to the complex
ıdy of contemporary processes in natural and
claimed soils, as a basis for the develop-
ent of rational methods of their reclamation.

In addition to a great number of journal ar-
les on the hydrology of soils, A. A. Rode
olished a monograph on soil moisture, which,
ether with his work on the types of moisture
gime in soils, was awarded the V. V. Doku-
ayev gold medal. Studies on moisture avail-
le in the soils of newly reclaimed virgin land
the Altay region are conducted by a group
ıded by S. I. Dolgov. Because of the re-
ımation of large new areas in arid regions,
ere the availability of moisture to crops is
deciding factor, studies in this field are of
eat importance. This is evidenced by the
erest shown in them by local (provincial and
gional) organizations (Altay region, Stalin-
ıd Region and others).

The Institute also conducted studies on a
ientific basis for methods of improving soils,
melioration.

The principles of the problem of genesis and
lioration of solonetzic soils, worked out by
ademician K. K. Gedroyts, were developed
l elaborated. The laboratory of soil physics
l chemistry (headed by I. N. Antipov-
ratayev) has determined the lower limits for
onetz and solonetzic soils according to their
ıtent in exchangeable sodium, which is of
eat importance in the determination of the
ount of gypsum necessary for the melioration
solonetz. A new, biological method of
liorating solonetz of the chestnut zone during
igation was developed with the aid of field
tions (Yershov and Arshan'-Zel'men), which
ved to be satisfactory under conditions of
oduction. On the basis of the experience
ned during production, the Ministry of Agri-
ture, together with the Institute, worked out
lan for Government instructions for the in-
duction of this method into practical agri-
ture.

Work conducted by the laboratory of soil
lrology at the Dzhanybek Experimental Sta-
ı led to the development of scientific prin-
les for the agricultural (and silvicultural)
lamation of soils in the solonetz complexes
the Caspian lowland. These principles were
cessfully used on a production scale by
khozes (Pallas district, Stalingrad Region).
nust be noted, that the solution of practical
blems in the work of this laboratory and at
d stations of the Institute is connected with
development of scientific problems of soil
lrology, their salt and gaseous regimes, and
blems of the genesis of soils in the solonetz
nplex.

Members of the laboratory of soil hydrology
N. Skrynnikova), the biological and micro-
logical laboratory (A. V. Rybalkina), and the
l biology laboratory (B. N. Makarov) finished
ndard investigations on "Contemporary soil
cesses in reclaimed peaty soils of a high ash
tent." The investigations served as a basis
for characterizing the influence of meliorative and practical methods and the type of crops on the moisture, aeration, and nutritional regime and biochemical processes in the soils studied. Recommendations were made to increase the productivity of these soils.

The laboratory on genesis and melioration of saline soils (headed by V. A. Kovda) made large-scale soil melioration studies in the Trans-Caucasus (Kura-Araks expedition), in Baraba, in Central Asia, and is now conducting similar investigations in the Volga-Akhtubinsk flood plain and in certain regions of the Chinese People's Republic. In the course of these important studies (from the point of view of production), extensive and valuable material was collected, the analysis and generalization of which allowed certain conclusions to be made on geochemical problems of salt accumulation in soils, sub-soils and ground water, problems of the salt regime and the control of salinization of irrigated soils in Central Asia and the Trans-Caucasus, and also on the reclamation of saline and bog lands of Western Siberia, the Far East, northeastern China, and Sinkiang. On the basis of this work, a series of new principles in theoretical and practical melioration of saline and bog soils was established, which have a leading importance for production. It must be noted, in particular, that the laboratory has paid great attention to the substantiation and affirmation of drainage, as an effective means for desalinizing soils and purifying ground water. This point of view, which at one time was subject to sharp criticism from the dogmatic followers of the forage field system as a universal method for increasing soil fertility and controling salinization, is now widely adopted. This is reflected in the more numerous construction of drainage systems in the irrigated oases of Central Asia and the Trans-Caucasus.

The scientific results of the long-term research of the Institute in the field of delta soil formation in arid zones have been analyzed. Large-scale hydrotechnical construction in the USSR has reflected on the natural conditions of the lower stretches of rivers. Now we can foresee how it is going to affect agricultural production in the deltas of the Aral-Caspian Basin. We know that the deltas of many rivers of the world were, so to speak, the cradle of irrigated agriculture. In this respect, a number of countries of the Near East, China, India, etc., are interested in obtaining the results of studies made in this field. Two large monographs were published on these problems: "Outlines of the nature and soils of China," by V. A. Kovda, and "Soil formation and conditions for meliorative irrigation in deltas," by V. V. Yegorov.

Work on biological methods of increasing the fertility of soils includes studies on "The improvement of the nitrogen balance in sod-podzolic soils" by the soil biology laboratory of the Institute. This problem was included in the working program of the Institute 3 years ago and is being studied in small-plot experiments at the scientific-experimental farm "Snigiri." The experiment is designed to last 10 years in order to yield reliable results which would characterize the importance of various methods (individually and in combination) to the state of the nitrogen balance. However, the influence of individual factors, such as various types of crops, is determined within shorter periods. The experiment is accompanied by detailed determinations of the magnitude and chemical composition of crops, studies on the dynamics of soil moisture, the inflow of bound nitrogen into the soil with atmospheric precipitation, its outflow with lysimetric waters, as well as special greenhouse and small-plot experiments on the role of the Azotobacter and application of various organic materials in the nitrogen balance of soils. In order to finish this review of the experimental work of the Institute, we must dwell on the work of the laboratory of soil biochemistry and microbiology and that of the laboratory of soil mineralogy.

The main attention of the laboratory of soil biochemistry and microbiology is concentrated on the study of organic matter in soil, namely: a) on the comparative study of the nature and properties of humic matter in the major soils of the USSR; b) on the biochemical process of humus formation and the role of humic matter in plant physiology and biology; and c) on the study of the microflora of soils and decay processes of organic matter in peat-bog and flood-plain soils.

Comparative studies on humic matter have been made for the major soil groups in the USSR. The laboratory uses the method of chemical investigation according to the scheme proposed by I. V. Tyurin for the study of the nature of humic matter, together with methods of optical, X-ray and luminescence analysis, and methods of infrared spectroscopy and chromatography (under the supervision of M. M. Kononova) in its comparative study of humic matter.

On the basis of the experimental investigations of the laboratory, the biochemical nature of the formation of humic matter under the influence of microorganisms was defined. The laboratory also obtained promising results in the use of small amounts of humic matter for stimulating the development of plants and increasing crop yield. The laboratory takes part in the complex problem of soil structure by studying the role of humic matter in the formation of the soil structure.

An important result of the work of the laboratory of soil biochemistry and microbiology is the publication in 1958 of the monograph "The microflora of soils in the European USSR" by A. V. Rybalkina and Ye. V. Kononenko.

The work of the soil mineralogy laboratory (headed by N. I. Gorbunov) was directed in the past years toward the study of the mineral composition of soils with the objects of determining the principles of the distribution and formation of secondary minerals in soils, of clarifying the influence of highly disperse minerals on soil properties and fertility, and of perfecting methods of determining soil minerals. The laboratory conducted these investigations within the framework of various expeditions by the Institute in the USSR, as well as in other countries, which allowed the collection and analysis of vast materials and both interesting scientific and practical generalizations.

In the field of the methodological investigations it was determined that diagnostic indices of clay minerals are not constant, depending on the degree of their dispersion and the composition of adsorbed cations. In relation to this, the laboratory worked out recommendations for the determination of highly disperse minerals by thermal and X-ray methods. The laboratory learned the micromorphological method of soil study, which allows a more detailed identification of the difference in the genesis and characteristics of soils.

III. Soil Erosion and Its Control

The work in this field is conducted by the soil erosion laboratory (headed by S. S. Sobolev).

The laboratory studies the geographical distribution of erosional processes and determines their causative factors. These studies are accompanied by comparisons of soil erosion maps for individual parts of the USSR and for the entire Soviet Union. One such map of the USSR is now being prepared for printing. It allowed assessment of the eroded soils of the USSR.

Studies have been conducted on the effect of erosion on crop yield of various soils and under various conditions of erosion, and a classification of eroded soils has been worked out. Six zonal systems of water and wind erosion control have been developed, taking into account the results of the laboratory's own long-term diversified permanent investigations in various regions of the chernozem, forest-steppe and sod-podzolic zones.

The laboratory prepared the project of the Instructions of the Council of Ministers of the USSR for soil erosion control measures in the USSR in agreement with the Ministry of Agriculture of the USSR and the All-Union Academy of Agricultural Sciences im. Lenin. Let us not dwell on the work of the Institute on the development and perfection of methods of soil study and investigation. Some of this work has been mentioned earlier together with the main themes of the plan.

That the work of Soviet soil scientists is of interest to people outside the USSR is evidenced by the translation abroad of a series of monographs by the members of the Institute into foreign languages (the monograph "Organic matter of soils", by M. M. Kononova, published in the German Democratic Republic, "Soil moisture" by A. A. Rode, published in the German Democratic Republic, Chinese People's Republic, Poland and Czechoslovakia; the monographic works of V. A. Kovda, V. A. Chernov and other members of the Institute were also published in China).

In closing let us touch on certain shortcomings in the work of the Institute, which should be corrected and eliminated in the future. In relation to this we must shortly discuss the problems of the future work of the Institute, taking into account its position as the main soil science institution in the system of the Academy of Sciences of the USSR and academies of the nion Republics.

The V. V. Dokuchayev Soil Institute is re-
oonsible for the development of future scien-
ic investigations in the field of soil science,
vestigations which should pave new ways for
e effective utilization of soil as the natural
oductive force and the fundamental means of
ricultural production.

What should these investigations consist of;
what directions should they develop? These
iestions stood before the Soil Institute for the
st 10 years, during which an intensive re-
nstruction of the contents and tasks of its
ientific research activity took place. Now
e main directions of further research work
ay be considered as sufficiently defined.

They consist first of all in the comprehensive
d profound study of soils as natural forma-
ons from the point of view of the future and
ssibilities of their productive exploitation in
nformity with the modern level of basic and
lated sciences. Second, in experimental in-
stigations directed toward the exploration and
velopment of ways to modify natural soils in
der to increase their productivity. Third,
pending on the particular soil properties and
e requirements of crops, in the determination
the optimum regimes of soil processes, as
gulated by agronomic and other means, for
taining constantly high and increasing crop
elds.

Briefly we may say that our main tasks are
e study and modification of soils for the needs
the national economy. These tasks were al-
the main tasks in the preceding period of
tivity of the Institute. However, now we need
raise the investigations in the previously-
entioned directions to a new, qualitatively
gher level, at which we must utilize our
rces and possibilities more rationally and
lly and use new means to accomplish our
sks. From this point of view let us point to
rtain essential shortcomings in our work,
ich have become apparent.

1. As was mentioned before, the Institute
ccessfully conducted work in the first direc-
on—the study of soils as natural formations—
neralized the material collected and investi-
ted new regions, especially in the eastern part
the country and in other countries. However,
e widening of the area and scope of investi-
tions was not accompanied by a sufficiently
ofound and varied study of newly discovered
pes of soil formations. Predominantly
andard methods of analysis were used for
eir characterization, which cannot be con-
lered sufficient even for well-known soils
d which often are not able to characterize the
sential features of unusual soils in new,
tle-known regions.

The insufficient corraboration of studies on
il geography with experimental investigations
the laboratories of the Institute cannot but
flect on the development of the problem of the
nesis of soil groups and weaken the foundation
the further development of the classifica-
n and systematization of soils, since in order
this development to be successful it is im-
rative that data be available on all characteristics of the composition and properties of soils belonging to various taxonomic categories. Unfortunately we do not have such data because up to now the Institute did not have the possibility of organizing systematic, complex work for this purpose. Data obtained by the various laboratories in their field are often uncomparable because they relate to different subjects.

Thus the difficult task of reconstructing our research program and organization stands before us. Such a program would require the united efforts of specialists in various fields to carry out the complex work of a comprehensive study of soils of various taxonomic categories and the clarification of the principles of their genesis and area distribution in relation to the continuous improvement of the classification and systematization of soils.

2. In addition to creating a complex of studies within the Institute, we must strive toward combining soil investigations with investigations of natural conditions of soil formation, i.e., geomorphological (and geological), climatological, geobotanical (and geozoological), hydrogeological, etc. Up to now these studies were not always properly combined.

3. In the second endeavor—modification of soils with the view toward creating conditions for higher soil productivity, the Institute was very successful (on the problem of the use of fertilizers and the development of new methods of soil tillage and melioration). However, a series of problems is not being studied as energetically as would be desirable and not always with the necessary complexity and scope.

The future tasks in this field, besides the elimination of the mentioned shortcomings, must include more profound studies of the theoretical principles of various methods and ways of influencing soil for increasing its productivity and the wider development of experimental investigations using the newest scientific and technical facilities. In relation to this it is necessary to achieve collaboration with the representatives of the basic sciences (physics, chemistry) and related branches (microbiology, plant physiology, biochemistry, etc.). In addition, it is imperative to strengthen and develop the existing scientific and experimental facilities of the Institute and organize new ones.

The following conclusions can be made from the foregoing. The V. V. Dokuchayev Soil Institute, being part of the system of the Academy of Sciences, grew to be the largest scientific center of soil science today. It was high authority in the USSR and is acknowledged internationally. It achieved great success in its knowledge of native soils and in the solution of problems related to the rational utilization and increase of the productivity of soils. We can clearly see our future problems, the solution of which requires all our efforts, and consider the shortcomings of the past, the elimination of which requires serious consideration.

All the experience gained makes us feel that the Institute, which has at its disposition great creative forces, will in the near future, reach a higher level of scientific investigation and achieve new successes in the knowledge of soils and their utilization and modification for the good of our country.

BIBLIOGRAPHY

SOIL FORMATION FACTORS, GENESIS, GEOGRAPHY AND CARTOGRAPHY OF SOILS

1. ADERIKHIN, P. G. and YE. P. TIKHOVA. 1959. Change in certain properties of chernozem soils in the Voronezh Region during irrigation. Byul. O-va yestestvoispyt. pri Voronezh. un-te. Vol. 11: 135-144. Bibliog. 9 refs.

2. ANTIPOVA, V. A. 1959. Characteristics of surface, loess-like clay loam in the Tomsk city area. Sb. nauch. tr. (Tomskiy inzh. -stoit. un-t. Vol. 5:94-98.

3. BOGOMOLOV, L. A. 1959. Interpretation of aerial photographs when mapping inaccessible regions. (Lecture given at the 7th All-Union Intradepartmental conference on aerial surveying). Tr. Laborat. aerometodov (Akad. Nauk SSSR). Vol. 7: 186-171.

4. BUCHINSKIY, I. YE. 1959. Climatic characteristics of dry winds in the Ukraine. Tr. Ukr. n. -i. gidrometeorol. in-ta. No. 18:10-29, with maps. Bibliog. 23 refs.

5. VOLKOV, I. A. 1959. Certain problems of the geomorphological interpretation of aerial photographs under steppe and desert conditions. (Lecture given at the 7th All-Union Intradepartmental conference on aerial surveying). Tr. Laborat. aerometodov (Akad. Nauk SSSR). Vol. 8:160-170.

6. VORONINA, K. V. 1959. Vegetation of the northern Caspian region at the time of the deposition of chocolate clays. Uchen. zap. (Sarat. un-t). Vol. 64:35-37. Bibliog. 7 refs.

7. GALKINA, YE. A. 1959. Use of aerial photographs for compiling intradepartmental landscape-geobotanical maps of bogs. (Lecture given at the 7th All-Union Intradepartmental conference on aerial surveying). Tr. Laborat. aerometodov (Akad. Nauk SSSR). Vol. 7:284-292. Bibliog. pp. 291-292.

8. GERASIMOV, I. P., L. R. SEREBRYANNYY, and N. S. CHEBOTAREVA. 1959. Anthropogenic (Pleistocene) deposits of Northern Europe and their stratigraphic components. Izv. Akad. Nauk SSSR. Ser. geogr. No. 6:3-21. Bibliog. pp. 20-21.

9. GOGINA, N. I. 1959. Analysis of physiographic conditions for the interpretation of aerial photographs when mapping the geology of Eastern Siberia. Izv. vyssh. uchebn. zavedeniy. Geologiya i razvedka. No. 8:27-36.

10. GRAVE, N. A. 1959. The main features and principles of development of permafrost in far northeast Asia. Izv. Akad. Nauk SSSR. Ser. geogr. No. 6:22-32. Bibliog. pp. 31-32.

11. YELKOVA, L. G. 1959. Certain data on soils of the Malaya Botuobi River Basin. Nauch. soobshch. (Yakutsk. filiala Sib. otd-niya Akad. Nauk SSSR). No. 2:51-56.

12. LEGEN'KAYA, YE. F. 1959. Experimental physiographic classification of the left bank of Saratov. Uchen. zap. (Sarat. un-t). Vol. 72:61-65, with maps. Bibliog. 5 refs.

13. LIKHOMAN, M. A. The Volga-Sarpin physiographic region within the limits of Astrakhan' Region. Ibid. pp. 73-78, with maps. Bibliog. 9 refs.

14. KOZ'YAKOV, S. N. 1959. Interpretation of syrts from aerial photographs. (Lecture given at the 7th All-Union Intradepartmental conference on aerial surveying). Tr. Laborat. aerometodov (Akad. Nauk SSSR). Vol. 7:308-309.

15. MATTISOV, A. YE. 1959. Agricultural classification of the Lower Volga region. Uchen. zap. (Saratov un-t). Vol. 72:41-47, with maps. Bibliog. 9 refs.

16. Method of constructing and using soil maps at kolkhozes and sovkhozes of the RSFSR. 1959. By N. P. Karpinskiy, N. K. Balyabo, V. A. Frantseson and A. I. Lyakhov. (All-Union Research Institute of Fertilizer and Agronomy). Moscow, Izdatel'stvo Moskovskogo sel'skogo khozyaystva. 115 pp. Bibliog. 19 refs.

17. OLYUNIN, V. N. 1959. Use of aerial photographs in the study of the relief of the Buryat ASSR. (Lecture given at the 7th All-Union Intradepartmental conference on aerial surveying). Tr. Laborat. aerometodov Akad. Nauk SSSR. Vol. 8:178-189.

18. ORLOV, V. I. 1959. Characteristics of the

distribution of certain forms of relief in the West Siberian lowland. Izv. Akad. Nauk SSSR. Ser. geogr. No. 6:107-111, with maps. Bibliog. p. 111.

PETROV, M.P. 1959. Vegetation of the deserts of Central Asia (Ordos, Alashan', Beyshan') and characteristics of its distribution. Botan. zh. 44(10):1387-1408, with maps. Bibliog. pp. 1407-1408.

PROKAYEV, V.I. 1959. Types of natural regions and natural boundaries. Izv. Akad. Nauk SSSR. Ser. geogr. No. 6: 128-134. Bibliog. p. 134.

KHUDYAKOV, I.I. and YE.K. KOKH. 1959. Vegetation as an index of the lithology and age of parent material according to observations in the northeastern part of the Trans-Volga region. Uchen. zap. (Sarat. un-t). Vol. 64:87-100, with maps. Bibliog. 5 refs.

TSEYTLIN, S.M. 1959. Glacial deposits in the basin of the middle stretches of the Nizhnyaya Tunguska River and their stratigraphic location. Tr. Geol. in-ta (Akad. Nauk SSSR). No. 32:115-121, with tables.

SHABANOV, M.A. 1959. Physiographic regions of the Trans-Volga syrt valley. Uchen. zap. (Sarat. un-t). Vol. 72:53-59, with maps. Bibliog. 14 refs.

BACHELIER, G. 1959. Etude péddologique des sols en Yooundé. Contribution à l'étude de la pédogénèse des sols ferralitiques. Agron. trop., Paris 14:279-305.

BEARE, J.A. 1959. Soils of South Australia. J. Agric. South Austr., 63(1): 22-28.

GERLACH, T. 1958. Preliminary investigations on the intensity of contemporary denundation processes at Yavorki near Shavnitsa. Rocan. Nauk Roln. Ser. F. 72(3):1281-1288. (In Polish).

GLENTWORTH, R. 1958. The geography of soils of Northeast Scotland. Agric. Progr. Vol. 33:58-64.

LÅG, J. and E. MORK. 1959. Jordsmonnet i Ulvsjøberget forsøksomrade. (The soils of Ulvsjøberget experimental area). Medd. Norske skogsforsøksves., 16, 41 pp.

MORI, T. and T. FUKAI. 1959. Studies on the heavy clay soils of Hokkaido effect of admixing sand with heavy clay soil. Res. Bull. Hokkaido nat. agric. Exp. Sta. No. 74:30-41. Ref.: Soils and Fertilizers, 1959: No. 6:2732.

MÜCKENHAUSEN, E. 1959. Die wichtigsten Böden der Bundesrepublik Deutschland 2-te Aufl. Frankfurt am Mair., 146 pp. Bibliog. 36 refs.

NAJMR, S. 1958. Ceskoslovensky soudoby pudoznalecky vyzkum. Sbornik Českosl. akad. zeměd. věd. Rostl. vyroba, 4:637-648.

32. PANIN, P.S. 1958. Brown soils in China. Tú Jang Hsüch Pao, 6:239-251. Ref: Chem. Abstr., 1959, 16:15435.

33. PONS, L.J. 1959. Fossiele bodenprofielen in het dekzand in de tunnelput van Velsen. (Fossil soil profiles in the sand covering the velsen excavation). Boor en Spade, 10:170-209.

34. Saline country Kansas, Washington, 1959. 175 pp. (U.S. Department of Agriculture Coll. "Soil Survey").

35. SCHAUFELBERGER, P. 1959. Klima-Klimaboden und Klimavegetationstypen. Geogr. helv. 1:35-43.

36. SIROVY, V. 1958. The effects of relief and the texture of soils on weathering and soil-forming processes in degraded chernozem. Sbor. Českosl. akad. zèměd. věd. Rostl. Vyroba. 4(6-7):693-714. Bibliog. Summaries in Russian, English and German. (In Czech).

37. Soil survey of Great Britain, London, 1958. 43 pp. Agric. Research Council. Soil Survey res. board.

38. Soil testing Agric. and Food Chemistry, 1959. 7(10):667-668.

39. SZEḰY-FUX, V. and K. SZEPESI. 1959. The role of loess in alkali soil formation. Acta geol. Acad. hung., 6:153-171. Ref: Soils and Fertilizers, 1959, 6:2731.

40. UBELL, K. 1959. Ground-water conditions in the southern part of Kischalfeld, in Hungary. Hidrol. közl. 39(3):165-175. Bibliog. (Summaries in German and English). (In Hungarian).

41. White Island soils. 1959. I. Baumgart, I. L., Pedology. 2. Stout, J.D. et al. Microbiology, N.Z. Dep. sci. industr. Res. Bull. 187:51-61.

SOIL MINERALOGY

42. GRIDNEV, N.I. 1959. Mineral and petrographic composition of contemporary alluvium on the right bank of the Amu-Dar'ya River Basin. Uzbeksk. geol. zh. No. 5:61-69. (Summary in Uzbek).

43. ACMINE, SH. and M.L. JACKSON. 1959. Allophane determination in Ando soils by cation-exchange capacity delta value. Soil Sci. Soc. America Proc., 23(3): 210-214. Bibliog. 213-214.

44. BLUME, H.P. and E. SCHLICHTING. 1959. Nachweis einer Tonverlagerung in Bodenprofilen. Z. Pflanzenernähr., Dung., Bodenkunde. Bd. 85(130). Ht. 3, pp. 227-244. Bibliog. p. 242.

45. BOWER, C.A. and J.O. GOCRTZEN. 1959. Surface area of soils and clays by an

equilibrium ethylene glycol method. Soil Sci., 87(5):289-292.

46. KULBICKI, G. and R. GRIM. 1959. A new method for thermal dehydration studies of clay minerals. Mineral Mag., 32(144):53-62.

47. MITRA, N.P. and H. SINGH. 1959. On the strong acid character of montmorilloritic clays and its disappearance on aging. Naturwissenschaften, Jg. 46, Ht. 9, pp. 319-320.

48. ORCHISTON, H.D. 1959. Adsorption of water vapor. 5. Homoionic illites at 25° C. Soil Sci., 87(5):276-282. Bibliog. pp. 281-282.

49. PAVEL, L. 1958. X-ray determination of clay soil minerals using the Czech microscopic X-ray apparatus "Micro-Meta." Sbor. Českosl. akad. zeměd. věd. rostl. výroba. 4(6-7):849-856. Bibliog. pp. 854-855. Summary in Russian. (In Czech).

50. SAWHNEY, B.L. 1958. Aluminum interlayers in soil clay minerals, montmorillonite and vermiculite. Nature, 182(4649): 1595-1596.

51. MEYER, B. and E. KALK. 1959. Die Mineralbestimmung in Tonfraktionen des Bodens mit Hilfe der Phasenkontrast- und Grenzdunkelfeldmikroskopie. Landwirtsch. Forsch., Bd. 12, Ht. 1, pp. 3-12.

52. SWINDALE, L.D. 1959. A one-dimensional Fourier investigation of a soil montmorillonite J. Geol. Geophys., 2:312-349.

53. WEY, R. et al. 1959. L'influence du pH sur l'absorption des cations par les argiles—Bull. Assoc. franç ét sol, 6:258-271.

PHYSICAL PROPERTIES OF SOILS AND METHODS OF INVESTIGATION

54. BYKOVA, V.S. 1959. Certain characteristics of the engineering and geological properties of loess-like materials in southern Ukraine on the left bank of the Dnepr River. Tr. Laboratorii gidrogeol. problem im. Savarenskogo. Vol. 22:75-86, with maps and tables. Bibliog. pp. 85-86.

55. BUSHMIN, A.P., and N.F. KUNIN. 1958. Mechanical compaction of soils. Uchen. zap. (Chelyab. ped. in-t). 5(1):199-205.

56. ZAVARINA, M.V. and A.V. KURBATOVA. 1959. Soil temperature distribution during the period of autumn frosts. Meteorologiya i Gidrologiya. No. 11:42-45.

57. KVASNIKOV, V.V. 1959. Theoretical problems of the soil structure in agricultural practice. Doklady Vses. akad. s.-kh. nauk. No. 12:3-8.

58. KONOVALOV, N.N. 1958. Comparative characterization of the hydrological and physical properties of soils of the left bank of the lower Don River. Sb. Tr. YUzhNIIGiM (Yuzhn. n.-i. in-t gidrotekhn. i melior.). No. 6:106-123. Bibliog. 13 refs.

59. LAPTEV, V.N. Experiment on the decreased filtration from rice paddies by barriers on the inner collection channels. Ibid. pp. 251-254.

60. MALYSHEV, F.A. 1959. Soil moisture dynamics after the application of hydropeat. Tr. In-ta torfa (Akad. Nauk BSSR). Vol. 8:332-342. Bibliog. 8 refs.

61. MALYSHEV, F.A. Change in the porosity of soil after application of hydropeat. Ibid. pp. 324-331. Bibliog. 9 refs.

62. MALYSHEV, F.A. Infiltration of solid peat particles from the hydropeat mass into the deeper soil layers. Ibid. pp. 314-323. Bibliog. 7 refs.

63. MALYANOV, A.P. 1959. Water distribution in the profile of soils in the presyrt valley of Western Kazakhstan when wetting them to field capacity. Uchen. zap. (Sarat. un-t). Vol. 64:209-211.

64. MALYANOV, A.P. Reserves in the structural improvement of the plowed layer in the soils of the Lower Volga region. Ibid. pp. 213-215.

65. MATYUNIN, N.F. 1959. Soil moisture determination by the alcohol method. S.kh. Tadzhikistana. No. 8:47-52.

66. SMIRNOV, G.A. and G.G. FEDOROV. 1959. The role of the mechanical redistribution of particles in sediments during diagenesis and the formation of stratification. Dokl. Akad. Nauk SSSR. 129(4):908-911. Bibliog. 8 refs.

67. TISHKOVICH, A. 1959. Investigation of the physical and mechanical properties of mixtures of peat nutrients and cubes. Tr. In-ta torfa (Akad. Nauk BSSR). Vol. 8: 352-363.

68. FEDOROV, B.V. 1959. The question of "lateral" and "loosening" of washouts of A.I. Kalashnikov. S.kh. Uzbekistana. No. 11:53-55.

69. SHALAMOV, B.S. 1959. Soil moisture measurement by the resistance of gypsum blocks. Nauch. soobshch. (Yakutsk. filiala Sib. otd-inya Akad. Nauk SSSR). No. 2:46-50. Bibliog. 6 refs.

70. YAKOVENKO, A.T. 1959. Change in the physical properties of dark chestnut soil in relation to the deepening of the plowed layer. Uchen. zap. (Sarat. un-t). Vol. 64:217-233. Bibliog. pp. 232-233.

71. BARLEY, K.P. and R.H. SEDGLEY. 1959. The influence of grass roots on the conduction of water through coarse-textured soils. Soils and Fertilizers, 22(3):155-156.

72. COOPER, A.W. and M.L. NICHOLS. 1959. Some observations on soil compaction

tests. Agric., Engng, 40(5):264-267.

DAVIDSON, J.M. et al. 1959. Influence of temperature on soil moisture neutron probes. Soil Sci. Soc. America Proc., 23(3):251-252.

HALADA, J. 1959. Results of observations of the moisture content of soil in the dry regions of Czechoslovakia. Sbor. Českosl. akad. zeměd. věd. rostl. výroba. 5(2): 275-290. Summaries in Russian, German, and English. (In Czech).

HARTGE, K. 1959. Der Einfluss des p-H-Wertes und der Kalkung auf die Strukturstabilität von Böden. Landwirtsch. Forsch., Sonderht 12, pp. 37-40.

HARTGE, K. 1959. Ursachen der Verbesserung der Strukturstabilität von Böden durch die Kalkung. Z. Pflanzenernär., Düng., Bodenkunde. 85(130):Ht. 3, pp. 214-227. Bibliog. pp. 226-227.

KAWAMURA, N. 1957. Characteristics of soil resistances of various shape moldboard plows. Bull. Univ. Osaka prefecture. Ser. B. Sakai, Osaka, 7:65-76.

KRISTENSEN, K.J. 1959. Temperature and heat balance of soil. Oikos, 10:103-120 (Copenhagen).

KOSMAT, H. 1959. Kontrolle der Bodenatmung durch akustische-elektrische Messungen. Bodenkultur, Ausg. A., 10: Ht. 2, pp. 130-140.

MOREL, R. and P. MASSON. 1959. Relation entre l'humidité des sols en place et le taux de matiere organique dans les parcelles du champ d'expériences de la Station agronomique de Grigno. Compt. rend. Acad. agric. France, 45(2):73-78.

PRIESTLEY, C.H.B. 1959. Heat conduction and temperature profiles in air and soil. J. Austral. Inst. Agric. Sci., 25: 94-107.

SCHACHTSCHABEL, P. and K. HARTGE. 1959. Die Messung der Bodenstruktur durch Bestimmung der pF-Kurve und der Strukturstabilität. Landwirtsch. Forsch., Sonderht 12, pp. 30-36 (In German).

SCHEUCH, G. 1959. Elasticité des argiles non saturées. Essais de chargement de plaques circulaires rigides. Compt. rend. Acad. sci. colon. 249(14):1194-1195 (In French).

STOLZY, L.H. et al. 1959. The use of a recording resistance bridge in soil moisture studies. Mich. agric. Exp. Sta. quart. Bull., 41:768-777.

TAYLOR, H. and J.A. VOMOCIL. 1959. Changes in soil compressibility associated with polyelectrolyte treatment. Soil Sci. Soc. America Proc., 23(3):181-183.

TJAGLO, G. 1959. Study of the structure-forming process and its relation to the yield of agricultural crops. Sbor. Českosl. akad. zeměd. věd. rostl. výroba. 5(2):225-256. Summary in Russian. (In Czech.)

87. TJAGLO, G. 1958. Study of the structure-forming process during crop rotation on chernozem and weakly podzolized soil. Sbor. Ceskosl. akad. zeměd. věd rostl. výroba. 4(6-7):715-742. Summary in Russian. (In Czech.)

88. TSCHAPEK, M. 1959. Concerning the forces of water retention by soils. Naturwissenschaften, 46, Ht. 2, pp. 71-72.

SOIL CHEMISTRY AND METHODS OF ANALYSIS

89. VOROPAYEVA, Z.YE. 1958. Change in the level and salt regime of ground waters in rice fields and adjoining areas. Sb. Tr. YUzhNIIGiM (Yuzhn. n.-i. in-t gidrotekhn. i melior.). No. 6:255-262.

90. VOROPAYEVA, Z.YE. 1958. Change of the physical and chemical properties of solonetz and terrace chernozem in constantly flooded rice fields under the conditions of Rostov Region. Ibid. pp. 227-241. Bibliog. 11 refs.

91. KONOBEYEVA, G.M. 1959. Changes in the chemical properties of takyr soils of ancient oases of the Kunyadar' valley after irrigation. Uzbeksk. biol. zh. No. 5:62-69. Bibliog. 16 refs. Summary in Uzbek.

92. KORENMAN, I.M. and B.A. NIKOLAYEV. 1959. Determination of potassium by its natural radioactivity. Tr. po khimii i khim. tekhnologii (g. Gor'kiy). Vol. 1: 102-104. Bibliog. 11 refs.

93. KASHCHENKO, A.S. 1959. Seasonal variations in the composition of humus in sod-podzolic gleyed soils. Tr. Velikoluksk. s.-kh. in-ta. No. 1:57-63.

94. SOROKIN, YU.I. 1959. Method of determining carbonates, available carbon oxide and organic carbon in soils. Byul. In-ta biologii vodokhranilishch (Akad. Nauk SSSR). No. 5:48-50.

95. ARNOLD, P.W. 1958. Potassium uptake by cation-exchange resins from soils and minerals. Nature, vol. 182(4649):1594-1595.

96. BOURNERIAS, M. 1959. Analyse physiochimique des sols. From the book: Société botanique de Francé. Memoires, Paris. pp. 12-15 (In French).

97. BOWER, C.A. 1959. Cation-exchange equilibria in soils affected by sodium salts. Soil Sci., vol. 88(1):32-35.

98. BUTTERS, B. and E.M. CHENORY. 1959. A rapid method for the determination of total sulphur in soils and plants. Analyst, vol. 84(997):239-245.

99. CHAMBERLAIN, G.T. 1959. Trace elements

in some East African soils and plants. I. Cobalt, beryllium, lead, nickel and zinc. E. Afric. Agric. J., 25(2):121-125. Bibliog. 19 refs.

100. DE MUMBRUM, L.E. 1959. Exchangeable potassium levels in vermiculite and K-depleted micas, and implications relative to potassium levels in soils. Soil Sci. Soc. America Proc., vol. 23(3):192-194.

101. EBERTOVA, H. 1959. Method of determining the oxidation-reduction potentials in humate solutions, in compost and in the soil. Sbor. Českosl. akad. zemed. ved. rostl. výroba. 5(4):479-494. Bibliog. pp. 492-493. Summary in Russian. (In Czech).

102. FADRUS, H. 1958. Problem of the determination of the exchangeability of soil by the method of Kappen. Sbor. Českosl. akad. zeměd ver. rostl. vyroba. 4(6-7): 857-862. Summary in Russian. (In Czech).

103. FONTAA, P. and G. ROSSI. 1959. Complexometric determination of extractable iron in soil. Ann. Chim. (Roma), 49: 310-315. Ref: Chem. Abstrs, 1959, 16: 154, p. 38.

104. GILLY, G. 1958. Acidite et aluminum echangeable, Ann. Agron., ann. 9(5):679-691. Bibliog. pp. 690-691.

105. GRAHAM, E.R. 1959. Determining Sr-90 in soil by electrodialysis and ion exchange method. Soil. Sci. vol. 83(1):11-13.

106. HENRIKSEN, A. and H.L. JENSEN. 1958. Chemical and microbiological determinations of copper in soil. Acta agric. scand., Vol. 8(4):441-469. Bibliog. pp. 467-469.

107. HUTCHESON, T.B. et al. 1959. Potassium-sodium interrelationships. 2. Potassium and sodium interactions in mineral systems. Soil Sci., vol. 88(1):36-44.

108. JACKSON, M.L. 1958. Soil chemical analysis. Englewood, Cliffs, N.Y. 496 p.

109. MIRONE, P. and G. ROSSI. 1959. Spectrographic determination of trace elements in soils. Ann. Chim. (Roma). 49, pp. 306-309. Ref: Chem. Abstrs., 1959, No. 16: 15437

110. MULLER, J. 1959. Comportement du cuivre dans les sols pauvres en matiere organique. Bull. Assoc. franc étude sol. No. 6:295-299 (In French).

111. NAGY, Z. and S. POLYIK. 1959. Fluorometric preliminary determination of traces of aluminum in natural waters. Hidrol. közl. 39(3):243-244. Bibliog. Summaries in Russian and English. (In Hungarian).

112. OERTEL, A.C. 1959. Estimation of the trace element status of large areas of soil. Austral. Agric. Res. Vol. 10(1):58-70. Bibliog. pp. 69-70.

113. PISZCZEK, J. 1956. Mangan w glebach terenow fliszowych. Ann. Univ. M. Curie-Sklodowska. E. Vol. XI(2):31-49.

114. RAJAGOPALAN, C.K. 1959. Action of activated carbon on soil. Modras Agric. J. 46(8):311-312.

115. SAWHNEY, B.L. et al. 1959. Cation exchange capacity determination of soils as influenced by the cation species. Soil Sci., Vol. 87(5):243-248. Bibliog. pp. 247 248.

116. SHAPIRO, R.E. and M. FRIED. 1959. Relative release and retentiveness of soil phosphates. Soil Sci. Soc. America Proc. Vol. 23(3):195-198.

SOIL BIOLOGY AND MICROBIOLOGY

117. BABAYTSEVA, M.F. 1959. Influence of various drainage regimes on the microbiology of peat soils. Tr. Vses. n.-i. in-ta gidrotekhn. i melior. Vol. 34:103-116.

118. BRITSKIY, YA.V. 1959. The entomofauna of soil in the western forest steppe of the Ukrainian SSR. Author's summary of dissertation for a candidate's degree in biological sciences. (Ukr. akad. s.-kh. n.). L'vov. 15 pp.

119. VAULINA, E.N. 1959. Flora of soil Xanthophyta of Belorussia. Botan. materialy otd. sporovykh rasteniy. Totan. in-ta im. Komarova. Vol. 12:98-106.

120. VAULINA, E.N. Systematic consideration of the soil organism Plectonema puteale (Kirchn.) Hansg. Botan. materialy otd. sporovykh rasteniy. Ibid. pp. 19-22. Bibliog. 7 refs.

121. GEL'TSER, F.YU. 1959. The role of plants in the formation of humus in soils. Zemledeliye. No. 11:50-56.

122. YEMTSOV, V.T. 1959. Aerobic nitrogen-fixing microorganisms of the genus Clostridium, their distribution in soils a relation to higher plants. Author's summary of dissertation for a candidate's degree in biological sciences. (Mosk. gos in-t. Bibl. pochv. fak.). Moscow. 29 pp.

123. MEKHTIYEV, S.YA. 1959. Certain data on the microflora of various soils in Moldav Mikrobiologiya. 28(5):743-749. Bibliog. p. 748.

124. NOVOGRUDSKIY, D.M. 1959. Soil humus and microbiological factors of its formation. (In-t pochvoved. Akad. Nauk Daz-SSR). Alma-Ata, Izd. Akad. Nauk Kazak skoy SSR. 95 pp.

125. SAMSONOVA, S.P. 1959. Influence of drying by the lyophilic method on root-nodule bacteria. Author's summary of dissertation for the candidate's degree in

biological sciences. (Mosk. gos. un-t). Moscow. 14 pp.

STEBAYEV, I. V. 1959. Invertebrates in the soil of the Salekhard tundra and the change in their grouping under the influence of farming. Zool. zh. 38(10):1559-1572. Bibliog. pp. 1571-1572.

STEPANOVA, L. N. 1959. Influence of the prolonged use of mineral fertilizers on the content of toxic bacteria in sod-podzolic soils. Nauch. dokl. vyssh. shkoly. Biol. nauki. No. 3:243-247.

TIMOFEYEV, V. A. 1959. Microorganisms as indicators of the degree of mineralization of organic matter in the soils of the Kirgiz-Ala-Tau. Tr. Kirgizsk. n.i. in-ta zemledeliya. No. 2:159-168. Bibliog. 8 refs.

KHAVINA, E. S. and YA. I. RAUTENSHTEYN 1959. Influence of the pH of the medium on the separation of actinophages from podzolic soil. Mikrobiologiya. 28(5):736-742. Bibliog. 7 refs.

SHCHELOKOVA, S. S. 1959. Propagation of numerous bacteria in soil. Dokl. Akad. Nauk UzSSR. No. 10:57-60. Summary in Uzbek.

YUZHINA, Z. I. 1959. Role of microorganisms in the toxicity of soils in the Kola Peninsula. Author's summary of dissertation for a candidate's degree in biological sciences. (In-t mikrobiol. Akad. Nauk SSSR.). Moscow. 21 pp.

HOFFMANN, G. 1959. Vertlilung und Herkunft einiger Enzyme im Boden. Z. Pflanzenernähr., Düng., Bodenkunde, Bd. 85(130), Ht. 2, pp. 97-104. Bibliog. 103-104. (In German).

KNÖSEL, D. 1959. Ueber die Wirkung aus Pflanzenresten freiwerdender, phenolischer Substanzen auf Mikroorganismen des Bodens 2. Versuche mit p-Cumarsäurs, Ferulasäure und Vanillisäure. Z. Pflanzenernähr., Düng., Bodenkunde, Bd. 85(130), Ht. 1, pp. 58-66. Bibliog. pp. 65-66. (In German).

STOTZKY, G. and J. L. MORTENSEN. 1959. Effect of gamma radiation on growth and metabolism of microorganisms in an organic soil. Soil Sci. America Proc., Vol. 23(2):125-127.

VANCURA, V. and J. MACURA. 1959. The development of azotobacter in the oats rhizosphere and its effect on the yield. Folia microbiol., vol. 4(3):200-202. Bibliog. pp. 201-202.

TCHAN, Y. T. 1959. Study of soil algae--3. Bioassay of soil fertility by algae. Plant and Soil, vol. 10(3):220-232.

SOIL FERTILITY, FERTILIZERS, AND TILLAGE

ABOLINA, G. I. 1959. Experiment on the system of soil tillage, proposed by T. S. Mal'tsev, on gray soils of the dry-farming areas of Uzbekistan. S. kh. Uzbekistana. No. 10:69-72.

138. AVRAMOV, P. T. 1959. Change in the physical properties of soils and in the regime of nutrients during crop rotation with perennial grasses. Tr. (Ukr. n.-i. in-t rasteniyevodstva, selektsii i genetiki). Vol. 5:151-167.

139. BAMBERG, K. 1959. Reaction and liming of soil. 2d rev. ed. Riga. Latviyskoye Gosudarstvennoye Izdatel'stvo. 144 pp. with illustr. Bibliog. 21 refs. In Latvian.

140. BEKMUKHAMETOV, M. 1959. Use of gray-brown soils in Kzyl-Ordinsk Region. S. kh. Kazakhstana. No. 10:34-35.

141. BIRETSKIY, M. 1959. Increase in the fertility of light Polish soils. (Lecture given at the scientific methodology conference on the increase of the fertility and productivity of light soils). Minsk. 35 pp.

142. BOTOV, T. G. 1959. New devices for redistributing soil layers. In the book: Novelties in the mechanization of agriculture, Nauchno-tekhnicheskoye Obshchestvo sel'skogo i lesnogo khozyaystva. Moscow, Izd-vo M-vo s. kh. RSFSR. 28 pp. with illustr.

143. BUGAKOV, A. 1959. Fertility of solonetz in the hands of agronomists. Nauka i peredovoy opyt v s. kh. No. 10:65-68.

144. BAKAL, L. 1958. Effect of various forms of potassium fertilizers on the yield of agricultural crops on weakly-leached chernozem. Sb. tr. (Sumskaya sel'skokhozyaystvennaya opytnaya stantsiya). Kiev-Sumy. pp. 157-170.

145. BAKAL, L. Effect of ground phosphorite on the yield of agricultural crops on weakly leached chernozem. Ibid. pp. 103-109.

146. VANEYAN, S. S. 1959. Plants and absorption of water during mechanical surface irrigation. Tr. Vses. n.-i. in-ta gidrotekhn. i melior. Vol. 34:3-10.

147. VOYTENKO, M. R. 1959. Results of a study of the system of soil tillage by the method of T. S. Mal'tsev. Tr. (Ukr. n.i. in-t rasteniyevodstva, selektsii i genetiki). Vol. 5:107-126.

148. GRECHIN, I. P. and A. YA. KOGOTKOV. 1959. Experimental study of the oxygen regime in the soils of the sod-podzolic zone. Izv. Timiryazevskoy s.-kh. akad. No. 5:187-196. Bibliog. p. 196.

149. ZAKHAROV, V. V. The system of soil tillage in Novosibirsk Region. Tr. Novosib. s.-kh. op. stants. No. 1:7-53. Bibliog. p. 53.

150. ZAKHAROV, V. V. Pre-sowing and post-sowing rolling of soil in the forest-steppe of Western Siberia. Ibid. pp. 65-85. Bib-

liog. 25 refs.

151. ZUYEVA, N.P. 1958. Influence of the method of application of phosphate fertilizers on the yield of sugar beet and the availability of phosphoric acid in soil. Sb. tr. (Sumskaya sel'skokhozyaystvennaya opytnaya stantsiya). Kiev-Sumy. pp. 131-140.

152. IL'IN, V.B. 1959. Elements of the fertility of chestnut soils of Central Kulunda. Author's summary of his dissertation for a candidate's degree in agricultural sciences. (Mosk. s.-kh. akad. im. Timiryazeva). Moscow. 20 pp.

153. KEDROV-ZIKHMAN, O.K. 1959. Liming and the use of organic fertilizers on the light soils of Belorussia. (Lecture given at the scientific methodology conference on the increase of the fertility and productivity of light soils). Minsk. 13 pp.

154. KRUPSKIY, N.K. and E.I. VESHKO. 1959. Influence of liming on humus accumulation in peaty, weakly podzolized soils of forested areas and the increase of the fertility of these soils. Tr. Ukr. n.-i. in-ta pochvovedeniya. Vol. 4:17-34. Bibliog. 30 refs.

155. MAMCHENKOV, I.P. and N.N. MIKHAYLOV. 1959. Fertilizers in kolkhoz crop rotation in the non-chernozem belt. Zemledeliye. No. 11:38-44.

156. MENAGARISHVILI, A.D. and V.V. LEZHAVA. 1959. Instructions for industrial agricultural laboratories. Tbilisi. 327 pp. with illustr. In Georgian.

157. NARTSISSOV, V.P. 1959. Necessity of discounting moldboard plowing in Gor'kiy Region. Zemledeliye. No. 11:61-67.

158. OZOLS, K.V. 1959. Physical conditions in spring wheat fields when cross- or narrow-row sowing and their effect on yield. Author's summary of dissertation for a candidate's degree in agricultural sciences (Vses. akad. s.-kh. n. im. Lenina. Agrofiz. n.-i. in-t). Riga. 23 pp.

159. PETERBURGSKIY, A.V. and F.V. YANISHEVSKIY. 1959. Study of the behavior of potassium in sod-podzolic, coarse clay loam under prolonged use of fertilizers in unrenewed fallow under rye and potato. Izv. Timiryazevskoy s.-kh. akad. No. 5: 75-94. Bibliog. pp. 93-94.

160. Plant nutrition and the use of fertilizers. Part I. Tr. Vses. n.-i. in-ta udobr. i. agropochvovedeniya (VIUA). No. 33. 204 pp. with illustr.

161. SAKHAROV, N.I. 1959. Deep plowing without a moldboard in sod-podzolic clay loam soils. Tr. (Vologodsk. molochnyy in-t). No. 43:411-422.

162. TARASENKO, B.I. and P.V. NOSOV. 1959. Field method of determining the availability of phosphorus and nitrogen to plants. S.kh. Sev. Kavkaza. No. 11:29-30.

163. TYUMENTSEV, N.F. and N.I. LUK'YANOV 1959. Experiment on the economical evaluation of soils in the kolkhozes of Tomsk Region. Tomsk, Knizhnoye izdatel'stvo. 63 pp.

164. FILIPPOV, L.A. 1959. Critical soil moisture for plants. Nauchn. tr. (Ukr. in-t fiziol. rasteniy). No. 20:25-31. Bibliog. 15 refs.

165. SHAIN, S.S. and V.M. KASHMANOV. 1959. The role of roots of perennial grasses which penetrate into the subsoil. Zemledeliye. No. 11:56-61.

166. EDRYUS, U.B. 1959. Use of organic and mineral fertilizers (on various soils and under various crops). Translated from the English by T.S. Chebanova. Edited by N. S. Sokolov. Moscow, Izd. inostr. lit. 399 pp. with illustr.

167. Abhängigkeit der Wirkung mineralischer Düngung von Höhe und zeitlichem Verlauf der biologischen Aktivität des Bodens. Agrochemica, Vol. 3(1):1-15. 1958 (In German).

168. ATANASIU, N. 1959. Zur Wirkung schwerlöslicher N-Verbindungen. Z. Pflanzenernähr., Düng., Bodenkunde, Bd. 84, Ht 1-3, pp. 103-110. Bibliog. pp. 109-110. (In Germa

169. BALLA, AL. 1958. Study on the availabilit of nutrients in manure. Agrokem. es. talaj. 7(3):233-242. Bibliog. pp. 241-242. Summaries in Russian and German. (In Hungarian).

170. BROESHART, H. 1959. Fertilizer placement studies by means of radioisotopes. Z. Pflanzenernähr., Düng., Bodenkunde, Bd. 84, Ht. 1-3, pp. 76-80.

171. DELMAS, J. 1958. Recherches sur la fertilisation des sols sableux sur defriche de lande. Bull. Assoc. Franc étude sol. 7:361-389. (In French).

172. BOGUSLAWSKI, E. VON. Das Zusammenwirken von Gründüngung und Stickstoffdüngug auf den C- und N-Umsatz im Boden. Z. Pflanzenernähr., Düng., Bodenkunde. Bd. 84, Ht. 1-3, pp. 85-93.(In German).

173. GASSER, J.K.R. 1959. Soil nitrogen. IV. Transformations and movement of fertilizer nitrogen in a light soil. J. Sci. Food and Agric., Vol. 10(3):192-197.

174. EBERHARDT, W. and G. KRZYSCH. 1959. Stickstoffgehalt und C/N-Verhaltnis eines lehmigen Sandbodens und ihre Abhängigkeit von Pflugarbeit und Düngung. Z. Pflanzenernähr., Düng., Bodenkunde. Bd. 85(130): Ht. 2, pp. 117-123. Bibliog. pp. 122-123. (In German).

175. Effects of plant decomposition products in the soil. 1958. Nature, Vol. 182(4651): 1-17.

GISIGER, L. and H. PULVER. 1959. Von Eigenschaften der Rohphosphate und ihrer Wirkung als Dünger. Agrochimica, Vol. 3 (2):165-189 (In German).

HAGIN, J. and S. RAVIKOVITCH. 1959. Development of a soil test for nitrogen availability to corn in Israel. Z. Pflanzenernähr., Düng., Bodenkunde. Bd. 84, Ht. 1-3, pp. 110-116.

HALSBACH, J. 1958. Determination of the wilting point of plants on certain soil types. Sbor. Českosl. akad. zeměd. věd. rostl. vyroba 4(6-7):649-660. Summaries in Russian and German. (In Czech.)

KANWAR, J.S. and J.S. GREWAL. 1958. Behaviour of different phosphatic fertilizers in Punjab soils. J. Indian Soc., Soil Sci., Vol. 6(4):215-222.

KAWE, A. 1959. Methode zur Bestimmung des Düngerbedürfnisses des Bodens für Kalk, Kalium und Phosphorsaure mit Hilfe der Bodenlösung. Z. Pflanzenernähr., Düng., Bodenkunde. Bd. 84, Ht. 1-3, pp. 224-231 (In German).

KERESZTENY, B. 1958. Influence of the reaction of soil on the effectiveness of mineral fertilizers. Agrokem. es talaj. 7(3):223-232. Summaries in Russian and French. (In Hungarian).

LUDWIEG, F. 1959. Bestimmung der radiochemischen Verunreinigung der Phosphorsäure in bestrahlten Phosphatdungern. Z. Pflanzenernähr., Düng., Bodenkunde, Bd. 84, Ht. 1-3, pp. 81-85. (In German).

MARSDEN, A. and I. L. STANSFIELD. 1959. Ammoniacal liquor as a fertilizer—effect of various constituents on the activity of microbiological flora. J. Sci. Food and Agric., Vol. 10(4):201-206.

MAREL, H.W. VAN DER. 1959. Potassium fixation, a beneficial soil characteristic for crop production. Z. Pflanzenernähr., Düng., Bodenkunde, Bd. 84, Ht. 1-3, pp. 51-63.

MIDDELBURG, H.A. 1959. Climate and nitrogen effect in relation to placement of fertilizers. Z. Pflanzenernähr., Düng., Bodenkunde, Bd. 84, Ht. 1-3, pp. 93-98.

NOVAK, B. 1958. Green manure fertilizers from the microbiological point of view. Sbor. Českosl. akad. zeměd. věd. rostl. vyroba. 4(6-7):791-798. Bibliog. pp. 797-798. Summaries in Russian, English and German. (In Czech.)

OBREJANU, GR. 1959. La fertilité des soils de la région inondable du Danube. Z. Pflanzenernähr., Düng., Bodenkunde, Bd. 84(129): Ht. 1-3, pp. 30-36.

SPICKA, A. 1958. Influence of various amounts of irrigation on the yield of field and meadow crops and on the physical properties of soil. Sbor. Českosl. akad. zeměd. věd. rostl. výroba. 4(6-7):775-790. (In Czech.)

189. THOMAS, G.W. and N.T. COLEMAN. 1959. A chromatographic approach to the leaching of fertilizer salts in soils. Soil Sci. Soc., America Proc., Vol. 23(2):113-116.

SOIL MELIORATION

190. ABDUYEV, M. 1959. Experimental leaching of saline soils of Diluvial origin under conditions of the Azerbaydzhan lowland. Khlopkovodstvo. No. 12:39-43.

191. ANTIPOV-KARATAYEV, I.N. and K.P. PAK. 1959. Transforming solonetz into a fertile land. Zemledeliye. No. 11:44-50.

192. BADENKO, I. 1959. Melioration and use of saline soils. S. kh. Kazakhstana. No. 9: 12-15.

193. BIRKAYA, A.F. 1958. Meliorative measures for the drainage and reclamation of the Kolkhida lowland. Tr. Gruz. n.-i. in-ta gidrotekhn. i melior. No. 20:55-77.

194. BOL'SHAKOV, A. 1959. Reclamation of solonchak-like solonetz in the north Caspian region. Kolkhzn. proizvodstvo No. 11:41-42.

195. VOZNESENSKIY, A.S. 1958. The drying effect of mole draining and the sowing of grasses on the bog areas of Kolkhida. (According to moisture tensiometer data). Tr. Gruz. n.-. in-ta gidrotekhn. i melior. No. 20:78-87.

196. VOZNYUK, S.T. 1959. Certain agricultural meliorative and productive characteristics of peaty soils in the flood plain of the Trubezh River in relation to processes of their salinization. Tr. Ukr. n.-i. in-ta pochvovedeniya. Vol. 4:35-64, with maps. Bibliog. 54 refs.

197. VOLOBUYEV, V.R. 1959. Leaching rates for the melioration of saline soils. Gidrotekh. i melior. No. 12:18-24. Bibliog. 12 refs.

198. DZHUMBAYEV, O.M. 1959. Saline soils of Turkmenistan and methods of improving them. Ashkhabad, Turkmengosizdat. 56 pp. In Turkmen.

199. YEGOROV, V.V. 1959. Soil formation when meliorative irrigation measures are taken in the deltas of the Aral-Caspian lowland. (Pochv. in-t im. V.V. Dokuchayeva). Izdatel'stvo Akad. Nauk SSSR. 296 pp. with illustr. and maps. Bibliog. pp. 278-295.

200. YEMEL'YANOV, V.A. and A.I. ZAYTSEV. 1959. Results of the use of radioactive isotopes in melioration investigations. Vestn. s.-kh. nauki. No. 11:103-109. Bibliog. 14 refs.

201. KOLPAKOV, V.V. 1959. Agricultural analysis and calculation of the water consumption of agricultural crops in the dry regions of the European SSSR. Author's summary of dissertation for a doctor's

degree in agricultural sciences. (Mosk. s.-kh. akad. im. Timiryazeva). Moscow. 56 pp.

202. KOS'MIN, I.M. 1959. The problem of the influence of krotovina on the water regime of drained, fine clay loam soils. Nauchn. tr. (Kaliningr. obl. opyt.-meliorat. st.). No.1:93-108, with tables.

203. KRIVONOSOV, I.M. Percolation in soil in drained agricultural lands. Ibid. pp. 17-30.

204. KRIVONOSOV, I.M. Experiment on the use of aerial methods for mapping and studying drainage systems. Ibid. pp. 64-83.

205. KRIVONOSOV, I.M., N.I. MORGUNOV, and L.N. SIDONTSEV. Certain constructive properties of drainage systems in Kaliningrad Region. Ibid. pp. 50-63, with maps and tables.

206. KRYLOV, M.M. 1959. Principles of the meliorative hydrogeology of Uzbekistan. Tashkent, izdatel'stvo Akad. Nauk Uzbekskoy SSR. 236 pp. with maps. Bibliog. 169 refs.

207. MAKAROVA, V.S. 1959. Determination of the projected total water consumption during irrigation by the thermal balance and exchange coefficient methods. Tr. Vses. n.-i. in-ta gidrotekhn. i melior. Vol. 34:66-76. Bibliog. 20 refs.

208. MORGUNOV, N.I. and A.I. AGAPOV. 1959. Certain results of work conducted by the Kaliningrad regional experimental-meliorative station from 1948-1958. Nauchn. tr. (Kaliningr. obl. opyt.-meliorat. st.). No.1:3-16.

209. NAUMOVA, A.N. 1959. All-Union conference on the reclamation and cultivation of solonetz lands. (Stalingrad, June, 1959). Izv. Akad. Nauk SSSR. Ser. biol. No.6:947-949.

210. ORLOVSKIY, N.V. 1959. Principal methods of reclamation and cultivation of saline soils. Vestn. s.-kh. nauki. 10:24-34.

211. SALIVERSTOV, M.N. 1959. Principal instructions for the reclamation of mineral lands overgrown with brush in the northwestern zone (Sev. NIIGIM). Leningrad. 19 pp.

212. SUDONTSEV, L.N. 1959. Moisture in the upper soil layer as an index for mapping drainage systems. Nauchn. tr. (Kaliningr. obl. opyt.-meliorat. st.). No.1:84-92, with maps.

213. TAIROV, M.A. and N.M. KRIVONOSOV. 1959. Agricultural melioration according to experience gained at kolkhozes and sovkhozes of the northwestern zone of the RSFSR. Leningrad, Lenizdat. 175 pp. with illustr.

214. KHODASEVICH, B.G. 1959. Method of calculating the economical effectiveness of meliorative measures. Gidrotekhn. i. melior. No.12:3-9.

215. CHILINGAROVA, L.V. 1958. Experiment reclamation of highly salinized soils on t right bank of the Alazan valley. Tr. Gru n.-i. in-ta gidrotekhn. i melior. No.20: 38-43.

216. SHUMADOV, B.A. 1958. The main principles in planning basin irrigation. Sb. Tr. YUzhNIIGiM (Yuzhn. n.-i. in-t gidrotekhn. i melior.). No.6:65-67.

SOIL EROSION AND ITS CONTROL

217. BOCHKOV, A.P. 1959. Influence of the degree of plowing and local characteristi of small watersheds on runoff under conditions of Northern Kazakhstan. Tr. Gid in-ta. No.68:50-85. Bibliog. 11 refs.

218. BUACHIDZE, V.M. 1958. The problem o erosion from irrigation at Samgori. Tr. Gruz. n.-i. in-ta gidrotekhn. i melior. No.20:16-22. Bibliog. 7 refs.

219. VASHAKIDZE, O.N. 1958. Change in the erosional indices of chernozem-like soil of Samgori during irrigation. Tr. Gruz. n.-i. in-ta gidrotekhn. i melior. No.20: 33-37. Bibliog. 8 refs.

220. GUSSAK, V.B. 1959. Erodibility of soils, methods of investigation and certain related problems. Author's summary of hi dissertation for a doctor's degree in agricultural sciences (Uzb. akad. s.-kh. nauk). Tashkent. 41 pp.

221. LYUTTSAU, S.V. 1959. The role of the root system of woody plants in the movement of loose debris on slopes and the formation of relief. Vopr. geogr. Vol. 46:169-188. Bibliog. 6 refs.

222. TITOV, P.N. 1959. Soil erosion and the distribution of agricultural land in kolkhozes of Voronezh Region. Zap. Voronezhsk. s.-kh. in-ta. 29(1):75-85.

223. UGGLYA, KH. and A. NOZHIN'SKI. 1959. Use of a new instrument, the so-called deflation meter, in erosion studies. (Lecture given at the scientific-methodology conference on the increase of the fertility and productivity of light soils). Minsk. 12 pp.

224. ADAMS, J.E. et al. 1959. Interpretation of runoff and erosion from field scale pl on Texas Blackland soil. Soil Sci., Vol. (4):232-238.

225. CHEPIL, W.S. 1958. Soil conditions that fluence wind erosion. (Washington, U.S. Government Printing Office, 1958/IV, 4 cents. U.S. Dept. Agric., Techn. bull. No.1185). Bibliog. pp. 38-40.

226. KURON, H. et al. 1959. Fluoreszenzmik skopische Untersuchungen über die Wirk der Flächenerosion auf das Bakterienleb

in Lössböden. Z. Pflanzenernähr., Düng., Bodenkunde. Bd 85(130). Ht. 1, pp. 44-50. Bibliog. pp. 49-50. (In German).

OREST SOIL SCIENCE, AGRICULTURAL RECLAMATION

ANTIPOV-KARATAYEV, I. N. 1959. Tasks of irrigation silviculture in the arid southeastern USSR. Soobshch. In-ta lesa (Akad. Nauk SSSR). No. 12:12-26. Bibliog. p. 26.

AKHTYRTSEV, B. P. 1959. Influence of cutting in the economic activity of man on forest soils of the southern forest-steppe of Voronezh Region. Byul. O-va yestestvoispyt. pri. Voronezh. un-te. Vol. 11:145-153. Bibliog. 8 refs.

VLASOV, S. I. and N. M. ZAYTSEV. 1959. Forest shelterbelts under the irrigated conditions of the Caspian lowland. Tr. In-ta lesa (Akad. Nauk SSSR). Vol. 42: 98-131, with tables. Bibliog. 10 refs.

KOZHEVNIKOV, A. M. 1957. Transpiration of irrigated plantations and their effect on percolation and ground waters. Sb. aspirantskikh rabot (Bryansk. lesokhoz. in-t). No. 2:155-166, with tables. Bibliog. p. 166.

KONDRASHOV, B. V. 1959. Forest belts and water accumulation in the soil. (Tamb. obl. otd-niye O-va po raspr. polit. i n. znaniy). Tambov, knizhnoye izdatel'stvo. 16 pp. with illustr.

KORMILINA, YE. G. 1959. Forest growing properties of the hilly-valley dry-farming area of Samarkand Region. Author's summary of dissertation for a candidate's degree in agricultural sciences. (Uzbeksk. akad. s.-kh. nauk). Tashkent. 16 pp.

Sylviculture and the agricultural melioration of forests. 1959. (Collection of articles). (Vses. akad. s. kh. im. Lenina). Moscow, Sel'khozgiz. 327 pp. with illustr.

SARALIDZE, T. V. 1959. Influence of forest belts on the moisture balance of dark chestnut soils. Uchen. zap. (Sarat. un-t). Vol. 64:234-236.

SKORODUMOV, A. S. 1959. Influence of forest plantations on the climate and soils in the arid steppes of the Ukrainian SSR. Author's summary of dissertation for a doctor's degree in agricultural sciences. (Ukr. akad. s.-kh. n.). Kiev. 46 pp. with graphs.

SMIRNOV, V. N. 1958. Methods of soil investigation in forests for agricultural purposes. (Instructions on soil investigation in forests for students at forestry faculties of silvitechnical and silvicultural institutions of higher education). 1958. (Povolzhsk. lesotekhn. in-t im. Gor'kogo) Ioshkar-Ola. 56 pages. Bibliography 38 pages.

237. TIMOFEYEV, A. F. 1959. Certain problems of the effectiveness of forest melioration by drainage. Tr. Belorus. s.-kh. akad. 3(1):94-102. Bibliog. 11 refs.

238. KHUTORTSOV, I. I. 1957. The hydrological and soil-protective importance of forest litter in the mountain pine forests and deciduous forests of Buryatiya. Sb. aspirantskikh rabot. (Bryansk. lesokhoz. in-t). No. 2:139-153.

GENERAL, HISTORY OF SOIL SCIENCE

239. AVAYEV, M. G. 1959. The principles of agriculture. (Textbook for the preparation of agricultural cadres for non-specialized service). Kazan', Tatknigoizdat. 345 pp. with illustr. In Tatar.

240. BOYKO, V. F. and I. K. TSITOVICH. 1959. Agricultural laboratory. (Practical instructions). Moscow, Sov. nauka. 498 pp. with illustr.

241. BALAGANSKAYA, V. YE. 1959. Experimental soil investigation in kolkhozes of Odessa Region. Zemledeliye. No. 4:84-86.

242. BOGOMOLOV, G. V. 1959. At the international symposium at Teheran (on the problem of arid zones) and the 14th Session of the Consulting Committee on Arid Zones in 1958. Vestn. Akad. Nauk SSSR. No. 3:93-95.

243. BUSOV, A. I. 1959. Soil science on a geological basis. Methods, instructions and test assignments. (For students of the Faculty of Forestry of the All-Union Correspondence Institute of Forestry, Leningrad). Leningrad. 70 pp.

244. GILYAROV, M. S. 1959. All-Union conference on soil zoology. (Moscow, November, 1958). Izv. Akad. Nauk SSSR. Ser. biol. No. 3:464-466.

245. GILYAROV, M. S. 1959. International colloquium on soil zoology at Rothamsted and problems of soil fauna at the 15th International Zoological Congress. (July 1958). Zool. zh. 38(5):404-405.

246. GORSHENIN, K. P. 1958. The chair of soil science. 40th Anniversary of the Institute. Tr. Omskogo s.-kh. in-ta. Vol. 32:35-43.

247. DOKUCHAYEV, V. V. 1959. Collected works. Vol. 3. Cartography, and the genesis and classification of soils. (Introduction by S. Sobolev). Riga, Latgosizdat. 415 pp. with illustr. and maps. Bibliog. of the works and lectures of V. V. Dokuchayev, 228 refs. Compiled by L. Chebotareva. Translation into Latvian.

248. Yevgeniy Vasil'yevich Bobko. (1890-1959). 1959. Udobreniye i urozhay. No. 6:64, with portrait.

249. KACHINSKIY, N. A. 1959. Soil, its properties and life. Tashkent, Izdatel'stvo Akad.

Uzbek. SSR. 332 pp. with illustr. In Uzbek.

250. KACHINSKIY, N. A. 1959. Soil, its properties and life. Moscow, Izd. lit. na inostr. yaz. 424 pp. with illustr. and maps. Translation into Korean.

251. Intradepartmental conference of soil scientists of the Urals and the Volga Region. 1959. Summaries of lectures. (Akad. Nauk SSSR) Bashkirsk. filial). Ufa. 77 pp.

252. MAMAYEV, B. M. 1959. First All-Union Conference of Soil Zoology. (Moscow, November 1958). Zool. zh. 38(5):792-795.

253. PETERBURGSKIY, A. V. 1959. Practices on agronomical chemistry. 4th rev. and enlarged ed. (Textbook for institutions of higher education). Moscow, Sel'khozgiz. 550 pp. with illustr.

254. Soil science and agriculture. (Collection under the editorship of V. Ye. Yegorov). (Dokl. TSKhA. No. 42, Nauchn. conferentsiya). Moscow. 264 pp.

255. Soil science. (Collection of articles under the editorship of B. V. Nadezhdin). Tr. Vost.-Sib. fil. Akad. Nauk SSSR. No. 17, ser. biol. Blagoveshchensk. 176 pp. with illustr.

256. Soil science. 1958. (Collection of articles under the editorship of S. P. Ryzhov). Tr. Sredneaziatsk. gos. un-ta. No. 138. Biol. nauki, Book 34, Tashkent. 126 pp. with illustr.

257. Soil investigations in the Belorussian SSR 1959. (Collection of articles.) (Belorussk. gos. un-ta). Minsk, Izd-vo Belgos. un-ta. 188 pp. with illustr.

258. Problem of the fertility of soils in the Ukrainian SSR. 1959. (Collection of articles). Tr. Ukr. n.-i. in-ta Pochvovedeniya. Vol. 4. Khar'kov. 242 pp. with illustr. and maps.

259. Program for the course "Agriculture with basic soil science." 1959. For Soviet party schools. (Vys. partshkola pri TSK KPSS). Moscow, Izd-vo VPSH. 20 pp.

260. Symposium on Bashkirian soils (under the editorship of S. N. Taychinov). 1959. (Vses. O-vo pochvovedov pri Akad. Nauk SSSR, Bashkirsk. otd-niye). Ufa. 72 pp. with illustr.

261. SERDOBOL'SKIY, I. P. 1959. 70th Anniversary of the birth of Ivan Nikolayevich Antipov-Karatayev. Kolloidnyy zh. 21(2): 137-138, with portrait.

262. SKORNYAKOV, S. M. and M. I. KAMYNIN. 1959. Soil investigations and the applications of their results. Zemledeliye, No. 4:77-84, with maps.

263. TYURIN, I. V. 1959. Work on soil geography and experiments conducted by the Soil Institute of the Academy of Sciences of the USSR, their educational and practical value. 1959. (From a lecture given at a general meeting of the Department of Biological Sciences of the Academy of Sciences of the USSR, March 25, 1959). Izv. Akad. Nauk SSSR. Ser. biol. No. 4:599-611.

264. TYAGNO-PYADNO, M. G., A. A. ZHVACHKINA, and M. M. RAZUMOVA. 1959. Methodological instructions for laborator and practical exercises in soil science (Kuybyshev Agricultural Institute, Chair of soil science and agronomy). Kuybysh 104 pp. with illustr. Bibliog.

265. Problems for study on the subject "Genera agriculture with soil science." For students of correspondence courses in agricultural technical schools specializing in "Agronomy" and "Fruit and vegetable culture." 2d ed. 1959. (M-vo s. kh. RSFSR, Vses. zaochn. s.-kh. tekhn.). 41 pp.

266. CHAYANOV, S. K. 1959. Nikolay Aleksandrovich Dimo. (1873-1959, obituary). Vestn. s.-kh. nauki. No. 5:157-158, wit portrait.

267. BIN, YE et al. 1959. Physical and chemical soil analysis. Practical handbook fo soil scientists, agricultural and forestry workers. Peking. 172 pp. In Chinese.

268. Biography on tropical soil organic matter and its conservation. —"Mon-Bibliogr. Bull. Inter.—Afric. Bur. Soils and Rura Economy. Spec. Bull." 1957. 7(1-2):27 p

269. Bodenkunde und Düngerlehre. Fachkunde für Cärtner. Berlin. 1957. 206.

270. FOTH, H. D. and J. H. PRATT. 1959. Soil-root monoliths. Collection and preservation. Agron. J., 51(4):246-247.

271. GAUDY, M. 1959. Manual d'agriculture tropicale. Paris. 448 pp. (In French).

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